CHAPTER 3. AFFECTED ENVIRONMENT

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AREA OF ANALYSIS

The regional area potentially affected by the alternatives considered in this environmental impact statement is the 277-mile-long Colorado River corridor as it passes through Grand Canyon National Park in northwestern Arizona. Designated as a world heritage site in 1979, the Grand Canyon is perhaps the most spectacular river gorge in the world. The rock strata exposed by the downcutting of the Colorado River provides a unique view of the evolutionary history of the earth's crust over approximately two billion years. The ongoing geologic processes at work in the Grand Canyon are essential to the development of important ecosystems in both the terrestrial and aquatic realms, supporting habitat for threatened and endangered species. The corridor itself is eligible for designation as a historic district on the National Register of Historic Places. In addition, the Grand Canyon offers exceptional natural beauty with varied opportunities for visitors to access the resources. As a world heritage site, the Grand Canyon is not only a treasure for the United States but for the world's people as well.

For purposes of the impact analysis, the area of analysis includes about 2 miles on either side of the river to incorporate the nearby areas that are readily accessible by hiking to most river runners. Some areas over 2 miles from the river are also included if they are known to be visited by river runners (according to river guides, publications, and park staff). This area of analysis falls mostly within Grand Canyon National Park; however, the area also includes lands within the Navajo Indian Reservation, Havasupai Indian Reservation, and the Hualapai Indian Reservation.

For the socioeconomic analysis the regional area of potential impact includes lands adjacent to Grand Canyon, as well as communities in northern Arizona, southern Utah, and southeastern Nevada that have socioeconomic ties to river running in Grand Canyon. Lands adjacent to the park that may be affected by the preferred alternative include the Navajo Indian Reservation, the Havasupai Indian Reservation, and the Hualapai Indian Reservation, as well as Glen Canyon National Recreation Area, Lake Mead National Recreation Area, Grand Canyon-Parashant National Monument, Bureau of Land Management (BLM) lands to the north and west of the park, and Kaibab National Forest districts north and south of the park. A total of nine Native American tribes have cultural affiliation to Grand Canyon.

Distance along the river corridor is measured in river miles (RM), beginning with RM 0 at Lees Ferry and ending with RM 277 at Grand Wash Cliffs. Most river trips launch at Lees Ferry, which is in Glen Canyon National Recreation Area, approximately 1 mile upstream of the Grand Canyon National Park boundary. Within the 277 miles of Grand Canyon, boats can be taken out only at Diamond Creek (RM 225). Many trips terminate there, but continuing trips take out at South Cove on Lake Mead (18 miles beyond Grand Wash Cliffs). Prior to 2001 trips took out at Pearce Ferry on Lake Mead (3 miles beyond Grand Wash Cliffs), but due to drought conditions and low water levels, mud flats have made the Pearce Ferry takeout inaccessible.

Passengers can be exchanged throughout the trip at additional points where established hiking trails meet the river. Both commercial and noncommercial trip participants commonly hike in or out of the canyon at Phantom Ranch (RM 88), using either the Bright Angel Trail or the South Kaibab Trail. Many commercial passengers leave or join trips by helicopter at Whitmore

(RM 187) and below Diamond Creek at RM 262 in the Lower Gorge. Private and commercial HRR river trips also launch at Diamond Creek and take boats out at South Cove.

In addition to these launch and takeout locations, the area of potential effect includes 200 camping beaches and numerous attractions along the river corridor. These specific sites are considered the local area of impact. Attraction sites include side canyons (particularly those with perennial streamflow), archeological and paleontological sites, historic locations and properties, caves, springs, and hiking trails. Most recreational use occurs close to the river; however, river runners venture into side canyons to explore.

Types and level of recreational use in the Lower Gorge below the confluence of Diamond Creek vary greatly from those above RM 225. The primitive zone that starts at Lees Ferry (Zone 1) ends at Diamond Creek. From RM 225 to RM 260 the zone is a transitional one, changing from primitive to semi-primitive. From RM 260 to RM 277 the setting is rural natural, and below RM 277 the setting becomes urban on Lake Mead. Visitors to the Lower Gorge experience an increase in motorized use from upriver travel from Lake Mead, pontoon boat excursions, and helicopter tours and shuttles in the Quartermaster area (RM 259–RM 262).

NATURAL RESOURCES

GENERAL SETTING

The Colorado River corridor is canyon-bound for its entire length below Glen Canyon Dam, with the exception of its starting point at Lees Ferry. Here the river is accessible by road due to a natural break in the landscape after the river emerges from Glen Canyon and before it enters the Marble Canyon section of Grand Canyon. Immediately downstream from Lees Ferry the river begins to downcut through uplifted terrain, slicing through ever-deeper rock layers until the canyon walls rise over a mile above river level. These walls, generally alternating between cliffs of harder rock and talus-covered slopes of softer rock, dominate the terrain. Eleven Paleozoic era layers of rock rest on older igneous and metamorphic rocks. Over the course of its passage, the Colorado River winds into and out of the crystalline rock three times, forming the Upper, Middle, and Lower Granite Gorges. Tributary side canyons cut through the walls of Grand Canyon at frequent intervals.

Within the Grand Canyon the river is strongly influenced by both upstream and downstream dams. Glen Canyon Dam is located approximately 15 miles upstream of Lees Ferry in Glen Canyon National Recreation Area. Operated by the Bureau of Reclamation, this dam affects the volume, pattern, temperature, and sediment load of river flows in Grand Canyon. Hoover Dam, located about 70 miles downstream of the park boundary, has backed the waters of Lake Mead approximately 40 miles into Grand Canyon (at full pool), slowing current and burying the historic river channel under thick deposits of sand and silt. This has transformed the river into a lake (when water levels in Lake Mead are up) or a sluggish river meandering across a steadily widening cliff-bound floodplain (at lower lake levels).

The climate of the river corridor is generally arid; average annual precipitation ranges between 6 and 10 inches. Precipitation comes in the form of summer thundershowers and gentle winter rains; snow occurs infrequently. Temperatures are hot in the summer, with the average July maximum at Phantom Ranch (RM 88) exceeding 105°F. Winter temperatures are relatively mild, with the January maximum at Phantom Ranch averaging about 56°F and the minimum averaging about 37°F (Western Regional Climate Center 2003).

SOILS

GEOMORPHOLOGY OF THE COLORADO RIVER IN THE GRAND CANYON

Elevation at river level ranges from 3,100 feet above mean sea level at Lees Ferry to about 1,200 feet at Grand Wash Cliffs. The Colorado River descends an average of 8 feet per mile over the length of the canyon, with more than half of this drop occurring in roughly 160 rapids (Leopold 1969). The river is geologically constrained to a narrow width by steep bedrock canyon walls, large talus blocks, alluvial fans, and cobble bars. Rock type strongly influences the morphology of the river. Softer rocks offer less resistance and result in a wider valley, a meandering channel, and many cobble bars and sand deposits, while harder rocks are more resistant to erosion and

form a narrower channel with rapids and deep pools. As in many canyon rivers, coarse sediment delivered by flooding tributaries forms debris fans at the mouths of side canyons. These debris fans partially fill and constrict the river channel, creating the classic pool-rapid longitudinal profile of the Colorado River through Grand Canyon. Flows back up behind the constrictions to form quiet pools, then pour through the constrictions, producing rapids and downstream scour holes. Channel width expands downstream of the constriction, allowing low-velocity recirculation zones (eddies) to form along the shoreline. The majority of Grand Canyon's 160 plus rapids conform to this pattern (Kieffer 1985; Schmidt and Graf 1990).

DEBRIS FLOWS AND RAPIDS

Glen Canyon Dam traps the Colorado River's sediment supply in Lake Powell, leaving the approximately 750 tributaries of the Colorado River between Lees Ferry and the Grand Wash Cliffs as the only source of sediment for the river in Grand Canyon. The primary sediment transport processes in these tributaries are sediment-laden flash floods called debris flows, which contain 70% to 90% sediment by weight. In Grand Canyon debris flows begin as slope failures during intense rainfall. They can occur in weathered bedrock (particularly in soft shale or siltstone) or when runoff pours over cliffs onto consolidated colluvial slopes, triggering failure (the "firehose effect") (Griffiths, Webb, and Melis 1996).

Debris flows deposit poorly sorted sediment, including extremely large boulders, as debris fans in the Colorado River. Before the Glen Canyon Dam was constructed, large spring floods periodically reworked these deposits, reducing the constriction to a remarkably uniform value throughout the canyon (one-half the width of the river channel upstream of the fan). The dam reduced the magnitude and frequency of mainstem floods, which has limited the ability of the river to move large boulders in recently aggraded debris fans. As a result, constrictions created by post-dam debris flows are likely to remain narrower, increasing river flow velocities and turbulence in rapids. During high flows huge waves can form, as happened at Crystal Rapid in 1983. Rapids in Grand Canyon are likely to become more severe and may present hazards to river recreational use over time (Kieffer 1985).

SAND DEPOSITS

Sediments in the Colorado River range in size from boulders and cobbles to gravel, sand, and silt. The finer-grained sediments (sand sized and smaller) are the most important in terms of the relative abundance (99% of the total sediment load) and the extent of deposits (Kearsley, Schmidt, and Warren 1994). Sand is deposited in pools and along channel margins, but the largest and most common sand deposits are formed in the zones of recirculating current associated with the debris fans (Schmidt and Graf 1990). Sand deposits are an important component of the riparian ecosystem, providing low-velocity habitats for fishes, substrate for riparian vegetation, erosion protection for archeological sites, and campsites for river recreationists (Hazel et al. 2002; Rubin et al. 2002). The size, abundance, and distribution of the sand deposits that serve as campsites limit the river's recreational carrying capacity. Geomorphic studies of changes in the sand deposits, photo documentation, and the experience of river guides indicate that, since the completion of Glen Canyon Dam in 1963 sediment load in the river has

been reduced by approximately 90%, and erosive conditions have been created. Degradation (erosion) is exceeding aggradation (deposition of new sand), and sand is being transported downstream, eventually to Lake Mead.

Over the last 40 years sand deposits suitable as campsites have decreased dramatically in both size and abundance, and campsites have changed more than any other aspect of the river recreation resource during this time. Loss of sand is most pronounced above the confluence with the Little Colorado River (RM 61.5). Efforts to retard loss of sand from the system and rebuild beaches through dam operations have met with limited success. Under current operations as stipulated in the "Record of Decision" (USDI 1996), new sand entering the Colorado River from the tributaries is exported downstream within weeks to months, especially in Marble Canyon (Rubin et al. 2002).

The Adaptive Management Work Group, formed as a result of the Grand Canyon Protection Act and the Glen Canyon Dam *Final Environmental Impact Statement* (BOR 1995) and "Record of Decision" (USDI 1996) has made recommendations for future dam operations to address this issue. One recent recommendation includes scheduling dam releases in excess of power plant capacity (or 31,000 cubic feet per second [cfs]) after flooding in the Paria River delivers more than one million metric tons of fine-grained sediment to the Colorado River. The intent of such spike releases is to transport the new sand from the riverbed to higher elevation deposits farther downstream, thus rebuilding camping beaches (Hazel et al. 2002). The focus is on flooding in the Paria River (RM 1), one of the two primary contributors of sediment (along with the Little Colorado River) to the Colorado River in Grand Canyon; together, these rivers contributed about 12% of the annual average pre-dam sediments to Grand Canyon. Augmenting sediment by artificial means has also been proposed (Rubin et al. 2002).

Other factors contributing to the decline of Grand Canyon beaches include encroachment of both native and nonnative vegetation and erosion caused by flash floods in side canyons, precipitation runoff, wind, and human use.

BEACHES AND CAMPSITES

The recreational use carrying capacity is closely tied to the number, size, and location of beaches suitable for camping along the river corridor. Several attempts have been made to inventory beach campsites in Grand Canyon, as well as considerable work on the effects of Glen Canyon Dam and dam operations on beach abundance, size, and attributes. One of the most comprehensive campsite inventories was completed in 1993 by Kearsley and Warren. Subsequent studies have updated information on beach size and abundance on subsets of these beaches. The "adopt-a-beach" program that has been developed by the Grand Canyon Monitoring and Research Center, independent researchers, and the Grand Canyon River Guides has examined the effects of dam operation on various beaches (Kearsley, Schmidt, and Warren 1994; Kearsley 1995; Kearsley and Quartaroli 1996; Kaplinski et al. 2002; and Thompson 2002). In addition, in October 2002 Grand Canyon National Park initiated a biophysical impact monitoring study, including data on campable beaches and recorded as the number of available tent sites (Brown and Jalbert 2003). The most current data available were used in the Grand Canyon River Trip Simulator.

Currently a little more than 200 camping beaches in Grand Canyon are consistently identifiable from Lees Ferry to Diamond Creek and approximately 15 from Diamond Creek to Lake Mead. The precise number varies from year to year and may depend on recent water level regimes (including experimental floods to maintain or rebuild beaches); vegetation changes; erosion from tributary flooding, wind, or recreational use; regulations that prevent use of some camps with sensitive cultural or natural resources; and the specific methodological criteria regarding what beaches to count (e.g., what flow level defines availability of "low water camps," deciding how much vegetation encroachment or tributary erosion makes a camp unusable). The 1993 inventory by Kearsley and Warren identified 226 camps at normal flow levels between Lees Ferry and Diamond Creek, an average density of about one per mile. It also identified 37 camps that are only available at low flows. More recent partial inventories indicate there may be a smaller number of sites, as some of the beaches available a decade ago are no longer present. The 2003 beach inventory by Brown and Jalbert identified 214 campsites between Lees Ferry and Diamond Creek, of which only 55 were considered large enough to accommodate 36 people, 106 could accommodate up to 24 people, and 53 could accommodate 12 or fewer people (see Appendix I). In a survey of 31 campsites from Lees Ferry to Diamond Creek between 1998 and 2000, the total camp area above the 25,000 cfs discharge stage had decreased by 25% as a result of vegetation encroachment, wind deflation, erosion from precipitation runoff, and human traffic (Kaplinski et al. 2002).

It is clear that campsites are becoming smaller and less abundant (see Figure 3-1) and that this trend will persist. Because fewer campsites are available, river trips have camped on rock ledges and in areas that are far less desirable than sandy beaches. This trend will affect future park management decisions about recreational use in the river corridor.

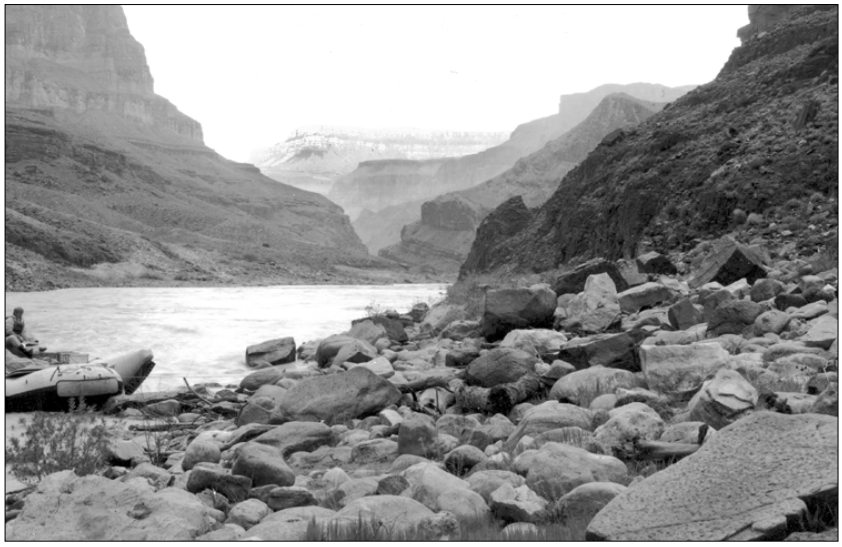
The distribution of campsites is not uniform through the canyon. In some reaches of the river campsite densities are lower, and large primary camps are particularly scarce. Geomorphologists and others have identified these as critical reaches, which typically correspond to narrower, gorge-like segments with higher flood water velocities. In critical reaches, which are 25 to 40 miles long, competition for the few most desirable camps can be a major issue. Erratic launch patterns and the location of specific attraction sites further exacerbate camp competition in these critical reaches, creating campsite bottlenecks. Examples of critical reaches include reach 2 (RM 11.3–RM 22.6), which contains two large beaches, and reach 9 (RM 139.9–RM 159.9), which contains only one large beach (see Appendix I; Brown and Jalbert 2003). Campsite competition occurs in the Lower Gorge also, where rafters and visitors traveling upriver from Lake Mead compete for 15 campsites along over 50 miles of river (see Appendix I).

LEES FERRY TO DIAMOND CREEK

Soils along the Colorado River corridor of the Grand Canyon occur in three hydrologic zones defined by Kearsley et al. (2003) — (1) shoreline (water's edge to the 25,000 cfs stage elevation); (2) new high-water zone (upper shoreline boundary to 90,000 cfs); and (3) old high-water zone (upper boundary of the new high-water zone to ca. 150,000 cfs stage elevation where vegetation grades into desert scrub). Xeric soils occur on talus slopes and cliffs above these hydrologic zones. In tributaries and at seeps and springs, riparian soils occur.

FIGURE 3-1: TAPEATS BEACH SIZE COMPARISON, 1952–1995

1952



1995

Soils near the shoreline are subject to scour and fill events from experimental releases from Glen Canyon Dam, which range as high as 31,000 cfs (power plant capacity) to 45,000 cfs (USDI 2002a). The new high-water zone is within the hydrologic zone that was last affected by flooding during the 1983–1986 flood flows; this zone is rarely subjected to scour and fill by fluctuating water flows. The old high-water zone is above any hydrologic zone that has been subjected to scour and fill since the creation of Glen Canyon Dam in 1963. Riparian soils occur in all three hydrologic zones (Kearsley et al. 2003) and at seeps or springs along the corridor or in tributary canyons.

Riparian soil textures in the inner canyon usually consist of sands, silts, sandy loam, or loamy sands that erode very easily and regenerate relatively slowly. Riparian substrates along the Colorado River are generally young alluvial deposits that are modified by hydraulic reworking, weathering, vegetation, wildlife, and recreational use (Stevens and Ayers 1993). Sediments for the most part consist of interbedded layers of fine silts, sand, and mixed-size particles. Soils in fluvial marshes are notably different; they are high in clayey silt, relatively low in sand, and can contain high levels of organic matter. Pre-dam sediments on the higher terraces (the old high-water zone) contain much more silt than do post-dam deposits. The flood releases of 1983 scoured alluvial deposits of fine silts and nutrients, generally increasing sand grain size and decreasing the ability of sediments to retain moisture. This reflects the low sediment load and highly erosive nature of the post-dam river. Nutrient concentrations are highest in pre-dam deposits (the old high-water zone) and shoreline marshes, and lowest in post-dam deposits (the new high-water zone and along the shoreline).

Above the new and old high-water zones, xeric soils on talus slopes and cliffs have been called skeletal and poorly developed (Stevens and Ayers 1993). They are assigned to the torriorthents-camborthids-rock outcrop association, which are generally shallow, moderately sloping to extremely steep, gravelly, cobbly and stony, moderately coarse to moderately fine-textured soils developed in colluvial material or on bedrock (Hendricks 1985; see Appendix C). The Natural Resources Conservation Service initiated a soil survey of Grand Canyon National Park in May 1998 and the soil types found above the hydrologic zones are listed in Appendix C. Soils on these talus slopes also contain a fine-textured component that was created when wind-deposited (eolian) materials filled in the spaces between boulders of talus slopes before Glen Canyon Dam was constructed (Lindsay 2003). Eolian sediments also fill spaces and fractures in Precambrian crystalline rock in the inner gorge.

Soils in the old high-water zone and above on the terraces can be relatively fragile and include biotic communities called biological soil crusts (NPS 2002c). Biological soil crusts are a complex mosaic of cyanobacteria, green algae, lichens, mosses, microfungi, and other bacteria (USGS 2001). Cyanobacteria and microfungal filaments weave through the top few millimeters of soil, gluing loose particles together and creating a highly irregular surface crust of raised pedestals (typically black and several centimeters tall). Biological soil crusts play a major role in preventing erosion, cycling nutrients, and providing sites for seed germination and plant growth (NPS 2002c).

Springs, seeps, and tributary soils can occur within or above the three hydrologic zones. Tributary soils are typically composed of gravelly streambed alluvium, with sandy or silty soil, cobbles, and other rock fragments up to boulder size (NPS 2002c). Soils in tributaries with perennial water generally contain more organic matter and exhibit lower pH. Thick riparian vegetation contributes substantially to the organic content of soils near streams, seeps, and springs.

DIAMOND CREEK TO LAKE MEAD

The same three hydrologic zones apply to soils in the Lower Gorge. Studies of shoreline erosion and beaches within the new high-water zone have been concentrated above the Lower Gorge, in

the Lees Ferry to Diamond Creek stretch. So little campsite information exists for the Lower Gorge campsites. Riparian soils found along the shoreline and in the new high-water zone below Diamond Creek are similar to the upper stretch in that they are young alluvial deposits consisting of sands, silts, sandy loam, or loamy sands. Old high-water zone soils consist of pre-dam sediments that are higher in clayey silt and contain biological soil crusts. As water levels in Lake Mead drop, mud flats and an elevated river bank have made it difficult to access attractions and campsites.

Soils located above the new and old high-water zones in the Lower Gorge are primarily rock outcrop-lithic torriorthents, typic torrifluvents or lithic torriorthents-lithic calciargids. Parent material consists of colluvium derived from schist and or sandy eolian deposits from mixed sources, alluvium or residuum weathered from calcareous shale (see Appendix C).

WATER QUALITY

GENERAL HYDROLOGY

Surface water resources in Grand Canyon consist of the Colorado River, tributary side streams, and seeps and springs. Colorado River flows entering the Grand Canyon are controlled through Glen Canyon Dam. Through the Grand Canyon the Colorado River gains water from perennial tributaries, flash flood flows in side canyons, and groundwater discharge through springs and seeps.

Colorado River Mainstem

Since the Glen Canyon Dam was finished in 1963, Colorado River flows through Grand Canyon have averaged about 13,700 cfs, with winter flows averaging less than summer flows. The maximum flow since 1963 was 92,600 cfs released during the unusually wet year of 1983; the minimum flow was 700 cfs, released when Lake Powell was filling (USGS 2003). Under normal operating criteria in effect since 1996, releases cannot exceed 25,000 cfs except during habitat maintenance or other experimental flows, under emergency conditions, or when required for flood control. Releases cannot drop below 8,000 cfs between 7 a.m. and 7 p.m. or 5,000 cfs at night. Daily fluctuations cannot exceed 8,000 cfs during high-release months (800,000 acre-feet [ac. ft.]), 6,000 cfs for medium-release months (600,000 to 800,000 ac. ft.), and 5,000 cfs for low-release volume months (less than 600,000 ac. ft) (BOR 1995).

Within the context the *Glen Canyon Dam Adaptive Management Program* (BOR, NPS, and USGS 2001), several experimental flows have been released since 1996, some lasting a few days, others a few months. These include a beach habitat building flow of 45,000 cfs in 1996, habitat maintenance flows of 30,700 cfs in 1997 and 30,300 cfs in 2000, high steady flows of 27,000 cfs in 1997, low steady summer flows with spike releases in 2000, and high fluctuating flows in 2003 and 2004. The intent of all experimental flows has been to improve natural resource conditions (Hazel et al. 2002; Thompson 2002).

Drought conditions have prevailed in the Colorado River basin for over four years. Inflows to Lake Powell were 62% of normal in 2000, 59% of normal in 2001, and 25% of normal in 2002. Total unregulated inflow for water year 2003 was projected to be about 60% of normal (BOR 2003c). Lake Powell's elevation was more than 90 feet below full pool in June 2003 and is expected to continue to drop if the drought endures. Because of these drawdown conditions in Lake Powell, releases from Glen Canyon Dam in 2003 were scheduled to meet the minimum objective release of 8.23 million acre-feet. Minimum annual releases can be expected until water levels in Lake Powell recover.

Tributaries

Of the over 750 tributary canyons in the Grand Canyon, the great majority are ephemeral watercourses, flowing only during local storm events. The largest tributaries with perennial flow are listed in Appendix D. The Paria and Little Colorado Rivers and Kanab, Havasu, Diamond, and Spencer Creeks originate outside the canyon, drain large plateau areas, and are major drainage features in Grand Canyon National Park. These tributaries derive flow from perennial runoff and perennial spring sources, as well as intermittent runoff events.

Perennial tributaries, in general, are popular attraction sites for river runners. Many of them offer clear water, lush vegetation, cascades, pools, and waterfalls. Angling is popular at cool-water tributaries like Bright Angel and Tapeats Creeks, which can be accessed by backcountry hikers.

Seeps and springs issue from thick sections of sedimentary rocks as the groundwater emerges into the canyon. Seeps and springs occur usually at the contact between a permeable rock unit and a non-permeable rock. Most of the springs issue from the Muav and Redwall limestones, although a few small springs issue from the Tapeats sandstone. If the seep or spring emerges on a cliff face, waterfalls and hanging gardens may develop. If the source of the spring is covered by rock fall, water may emerge at the base of a talus slope. Springs are the source of base flow in most of the perennial tributaries to the Colorado River. The largest springs in the Canyon — Blue, Havasu, Thunder River, and Roaring springs — provide base flow for the Little Colorado River, Havasu Creek, Tapeats Creek, and Bright Angel Creek, respectively.

Other large springs accessible from the river include Vasey's Paradise, Upper and Lower Deer Springs, and Pumpkin Spring. River runners generally make use of the streams and riparian areas downstream of the large springs rather than the point of emergence itself, which is often difficult to access. A major exception is Pumpkin Spring, which is a highly mineralized spring that fills a travertine bowl at the river's edge and was once commonly used as a warm-water swimming hole; it is now generally avoided because of high arsenic levels.

LEES FERRY TO DIAMOND CREEK

Colorado River Mainstem

Arizona Status. The Arizona Department of Environmental Quality (ADEQ) assesses the water quality of two stretches of the Colorado River below Glen Canyon Dam: the first from the dam to the Paria River (RM 0) and the second from Parashant Canyon (RM 198.5) to Diamond Creek

(RM 225). At the time of ADEQ's 1998 "Water Quality Limited Waters List," the first stretch was considered to have impaired uses because of elevated levels of selenium (ADEQ 1998). The second stretch was considered to have impaired uses because of high turbidity. In 2000 the department adopted new procedures and now reports their water quality findings based on whether or not a water body has attained established standards for certain water quality parameters for designated uses. Water quality parameters include temperature, pH, turbidity, total dissolved solids (TDS), numerous chemical elements and compounds, and pathogens (disease-causing microbes). Designated uses for the Colorado River below Glen Canyon Dam include agriculture, aquatic wildlife (cold-water fishery), domestic water source, fish consumption, and full body contact (swimming). In 2002 the stretch of the river from Parashant to Diamond Creek was considered impaired because turbidity levels exceeded ADEQ's standard (10 nephelometric turbidity unit [NTU]) for a cold-water fishery. Attainment for all other uses was judged inconclusive because of insufficient data given ADEQ's revised requirements (ADEQ 2002).

Physical Characteristics. Because it is drawn from deep within Lake Powell, Colorado River water in Grand Canyon is cold year-round, varying little with season. River temperatures at Lees Ferry average 46°F (BOR 1995). Seasonally, temperatures gradually warm from a low in February/March of 43°F to a maximum in December of 54°F (Hueftle and Vernieu 1998). From June through August temperatures slowly increase downstream until reaching about 60°F at Diamond Creek (Vernieu 2000; BOR 1995). Releases from Glen Canyon Dam are generally clear and low in nutrients owing to the lack of nutrient-rich sediments and algae (Wilson, Shannon, and Blinn 1999). Turbidity, nutrients, and total dissolved solids all tend to increase farther downstream from the dam owing to tributary inflows and side canyon runoff. During the last decade, total dissolved solids have fluctuated from 390 to 650 milligrams per liter (mg/L), with a typical annual fluctuation of about 130 mg/L (Vernieu 2000). River water is alkaline.

Pathogens. Water samples collected from the Colorado River and tributaries in Grand Canyon were examined for protozoan parasites (*Giardia* spp. and *Cryptosporidium parvum*, both derived from animal fecal material), enteroviruses (derived only from humans), and the bacteria *Escherichia coli* (derived from human and animal fecal material* (Gerba, Enriquez, and Gaither 1997). Samples were not tested for Norovirus (formerly called Norwalk-like virus). Three mainstem sites were sampled, and one site, RM 52, was sampled four times (June and August 1995, July and August 1996) for *E. coli* and parasites, and twice for enteroviruses. Results were positive once for *E. coli* (low count) and once for *Cryptosporidium*. No enteroviruses were found. Two additional mainstem sites were sampled once (June 1995) for *E. coli*, with unmeasurable results.

In earlier mainstem sampling, a correlation was found between increased total coliform levels and increased turbidity (Sommerfeld, Crayton, and Crane 1976). Bacteria adhere to sediment and are found in larger concentrations in bottom sediments than in the water column. Elevated bacteria counts in water, therefore, are associated with activities that entrain sediments, such as storm runoff and human wading.

* *E. coli* has increasingly replaced fecal coliform as an indicator of human pathogens in recreational waters (ADEQ 2002).

Several outbreaks of gastrointestinal illness have occurred among river users since 1972. Outbreaks in 1994, 2000, and 2002 involved more than 300 persons (Higgins 2002). Specimens taken from afflicted individuals in 2002 were positive for the enteric Norovirus, which originates only from humans. Samples collected from the mainstem near Lees Ferry and from the sewage treatment plant at Glen Canyon Dam also tested positive for the Norovirus. The study concluded that the virus most likely came from the sewage treatment plant and was being spread to recreationists through consumption of contaminated Colorado River water. To protect against illness-causing (or potentially causing) viruses, parasites, and bacteria, all of which have been documented from the Colorado River in recent years, the water should be settled (if cloudy), filtered, and disinfected with chlorine before being consumed.

Tributaries and Springs

State of Arizona Status. ADEQ's 2002 water quality assessment was inconclusive for Grand Canyon tributaries due to insufficient data; however, the 1998 "Water Quality Limited Waters List" reported four streams as having impaired uses for the parameters indicated: Paria River (beryllium, turbidity), Lava/Chuar Creek (turbidity), Royal Arch Creek (selenium), and Havasu Creek (turbidity).

Physical Characteristics. Grand Canyon's tributaries were found to be characterized by dissolved oxygen within the range of healthy streams and high alkalinities (Mazzu 1995). Spring-fed tributaries that emanate from the Redwall or Muav limestone formations of the North Rim (Vasey's Paradise and Saddle, Clear, Bright Angel, Shinumo, Stone, Tapeats, and Deer Creeks) generally have low TDS levels. Spring-fed streams that emanate from lower carbonate strata (Little Colorado River and Kwagunt, Nankoweap, Hermit, Crystal, Royal Arch, Matkatamiba, Havasu, National, and Spring Canyon Creeks) have higher TDS levels. Some of these streams have high levels of sulfate and/or arsenic or, more rarely, elevated levels of metals. Mazzu (1995) found levels of radioactive elements (radionuclides) to be above the natural range in the Paria River, Lava/Chuar Creek, Hermit Creek, and Kanab Creek, with levels in Kanab Creek at flood stage well above health standards. Oily discoloration has been observed in Kanab Creek, possibly indicating petrochemical contamination from an upstream source outside the park (Rihs 2003). Such discoloration may also be caused by naturally generating methane. (See Appendix D for a summary of available water quality information.)

Pathogens. During June and July 1995, and July and August 1996, 14 tributaries, 3 inflow areas, and 2 springs were sampled for *Giardia, Cryptosporidium*, enteroviruses, and/or *E. coli* (Gerba, Enriquez, and Gaither 1997). Waters from six sites tested positive for *Giardia* and/or *Cryptosporidium* — Vasey's Paradise and Nautiloid, Nankoweap, Bright Angel, Pipe, and Hermit Creeks. Vasey's Paradise tested positive for both parasites, and had the highest counts for both. No enteroviruses were detected at any of the 12 sites sampled. *E. coli* was detected in measurable amounts at 13 of the 19 sites sampled, with 6 sites registering counts of over 100 organisms per 100 ml. Of these, three sites exceeded the U. S. Environmental Protection Agency's (EPA) standard for *E. coli* in recreational water (235/100 ml): Nautiloid inflow, Royal Arch Creek, and Tapeats Creek. One sample from Tapeats Creek reached at least 900/100 ml. High counts may have been related to high runoff conditions, but the data were not sufficient to make this determination. The report concluded that the concentrations of parasites are low, and

tributary waters generally do not exceed health standards (Gerba, Enriquez, and Gaither 1997). Nonetheless, all drinking water should be taken from the middle of the Colorado River, and all water should be filtered and treated with chlorine to ensure purity before consuming.

Mazzu (1995) found that water quality of springs and tributaries in the Grand Canyon varied greatly with respect to fecal coliform and fecal streptococcus, but over the course of a 1992–1994 study most of the tributaries exhibited high bacteria levels at least some of the time. High bacteria levels generally, but not always, correlated with high turbidity. In a follow-up to Mazzu's work, park staff monitored 25 tributaries in the Grand Canyon for bacteria during June, August, and October 1995 (Rihs 1995). Fecal coliform levels were generally low for all sampling periods, and fecal streptococcus levels were generally high. Since fecal coliform is more correlated with human contamination, and fecal streptococcus is more correlated with wildlife contamination, the result "strongly suggests that the dominant contributor was wildlife" (Rihs 1995). Overall, bacteria levels were generally highest during the August trip. This timing may be related to higher discharge and turbidity resulting from summer storm activity, higher visitor levels in August, or both.

DIAMOND CREEK TO LAKE MEAD

Water quality issues in the Lower Gorge from Diamond Creek to Lake Mead are probably similar to those from Lees Ferry to Diamond Creek. In this section of the river, however, less monitoring occurs so there is less information. The Arizona Department of Environmental Quality does not assess water quality of the mainstem in this reach or the major tributaries such as Diamond Creek or Spencer Creek. The U. S. Geological Survey does not operate any monitoring stations on the mainstem below Diamond Creek. USGS volumetric data is available for Diamond and Spencer Creeks and for the mainstem just above Diamond Creek, but limited water quality data are available from the agency. The National Park Service has not inventoried or sampled tributaries or springs in the Lower Gorge, or the mainstem (Rihs, pers. comm. 2004).

The Hualapai Tribe has a water quality monitoring program and works in collaboration and cooperation with the U. S. Geological Survey. Forty-four seeps and springs and associated wetlands throughout the Hualapai Reservation are significant to the tribe and are monitored (Cabillo, pers. comm. 2004). Use of these water sources includes aquatic and wildlife, full body contact, domestic, fish consumption, and agriculture (irrigation and livestock). Lava Spring, Diamond Spring Canyon, Pumpkin Spring, and Three Springs are among the most well-known springs that the tribe monitors (Cabillo 2003). Pumpkin Spring is a warm spring at RM 213 that chronically exceeds state health standards for arsenic (naturally occurring), and the National Park Service advises recreationists to avoid it.

AIR QUALITY

GRAND CANYON AIR QUALITY

Clean, clear air is essential for park visitors to be able to appreciate Grand Canyon's most valued characteristics — the visual grandeur of its scenery, scale, form, colors, and wilderness qualities.

It is also important for the health of visitors, as well as tribal and local residents. Atmospheric conditions in and around Grand Canyon influence the diffusion of natural and anthropogenic emissions and affect the general air quality of the Grand Canyon. Temperature, precipitation, cloud cover, dew point, and other factors are relevant, but wind is particularly important for diffusing pollutants. Southerly and southwesterly directions throughout most of the year dominate prevailing winds in the region. There is, however, a significant northeasterly direction during winter. Prevailing winds tend to be strongest in spring and weakest in winter. Meteorological studies conducted in the 1980s indicate that once pollutants are introduced into Grand Canyon, they tend to recirculate within the canyon until removed by moderate to strong prevailing winds. This effect, coupled with temperature inversions, causes locations within the canyon to have generally have higher pollution levels than sites on the rims (Whiteman, Allwine, and Hubbe 1991; Bowman 2003a). Emissions from local sources, such as wildland fire smoke and dust generated on the Diamond Creek road on the Hualapai reservation, can also become trapped.

Temperature inversions may occur in the winter when cold, dense air drains into the canyon at night and is trapped by a cap of warmer air. Extended inversions have the potential to cause stagnant conditions in lower canyon elevations, and pollutants can become trapped, degrading air quality, creating hazy conditions, and impairing visibility. During winter, passing cold fronts can break up inversions and result in the clearest conditions at the canyon.

AMBIENT AIR QUALITY

Air pollution levels within Grand Canyon are generally low and within federal standards (EA Engineering, Science, and Technology 2002). The U. S. Environmental Protection Agency has promulgated national ambient air quality standards (NAAQS). Regulated pollutants include carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM), sulfur dioxide (SO_2), and lead (Pb). Areas within the United States where measured concentrations of these pollutants are above the national standards are known as non-attainment areas. All others are defined as attainment areas or are unclassified. Grand Canyon National Park and the Hualapai reservation are located in Coconino and Mohave Counties, which are both classified as attainment areas for all five pollutants. In accordance with the federal Clean Air Act, Grand Canyon has been mandated as a Class I area. This rating requires the most stringent protection against increases in air pollution and further degradation of air quality related values. Relative to the air quality related values, the Clean Air Act sets a goal of natural visibility conditions that are not impacted by human-caused visibility degradation. The Hualapai Nation of the Grand Canyon, through its Tribal Council, has passed a Hualapai Air Ordinance and is considering requesting the Environmental Protection Agency to redesignate its airshed to Class I.

Measured levels for PM, SO_2, and Pb at the park are well below the health-related national ambient air quality standards (see Table 3-1). Levels of O_3 are relatively high and have been trending upward since the late 1980s; however, measured values continue to meet federal and state ambient air quality standards. The other regulated pollutants, CO and NO_2, are not routinely monitored at Grand Canyon, although research in 2001–02 measured very low average CO levels in the southeast area of the park (averaging 0.12 ppm in the summer and 0.05 ppm in the winter) (Martin et al. 2002). Routine pollutant monitoring has been done in the eastern part of the park,

TABLE 3-1: FEDERAL AND ARIZONA AMBIENT AIR QUALITY STANDARDS FOR CRITERIA POLLUTANTS, AND AVAILABLE DATA FROM GRAND CANYON NATIONAL PARK, 1991–2000

Pollutant	Averaging Time	National Ambient Air Quality Standards	Maximum Measured at Grand Canyon (10-year average)		Maximum Measured at Grand Canyon (10-year range)	
			South Rim	Indian Garden	South Rim	Indian Garden
Ozone (O_3)	One Hour[a]	235	155.38	-	143.22–170.69	-
	Eight Hour[b]	157	135.96	-	125.56–143.22	-
Coarse Particulate Matter (PM_{10})	24 Hour[c]	150	26.51	32.01	18.27–44.99	22.50–45.78
	Annual[d]	50	8.42	10.63	7.37–9.65	8.62–11.78
Fine Particulate Matter ($PM_{2.5}$)	24 Hour[e]	65	8.04	9.91	6.65–9.28	9.11–11.15
	Annual[f]	15	3.30	4.38	2.99–3.56	4.00–4.94
Sulfur Dioxide (SO_2)	24 Hour[g]	365	3.0386	2.2961	0.0015–7.8409	0.5321–6.4359
	Annual[h]	80	0.2951	0.3641	0.0015–0.5052	0.2072–0.5077
Lead (Pb)	Quarterly[i]	1.5	0.00092	0.00114	0.00058–0.00165	0.00071–0.00181

SOURCES: US EPA 2004.

Bowman 2003b: Grand Canyon ozone data are from the NPS Gaseous Pollutant Monitoring Network station near Grand Canyon Village. Statistics were compiled by the National Park Service Air Resources Division. These data meet EPA standards for NAAQS evaluation.

All other Grand Canyon data are from the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitors GRCA1 (near Hopi Point, 1988-98) and GRCA2 (near Grandview Point, 1997-present); and INGA (at Indian Garden, 3200′ below the South Rim), filter samples made Wednesday and Saturday (1988 through September 2000), or every third day (October 2000 to present). PM_{10} and $PM_{2.5}$ data meet EPA standards for background monitoring only (not NAAQS attainment). SO_2 and Pb data are used to characterize concentrations but do not meet EPA standards for NAAQS evaluation.

Ozone:
a. 1 Hour: To attain this standard, the daily maximum 1-hour average concentration measured by a continuous ambient air monitor must not exceed 0.12 parts per million (ppm) more than once per year, averaged over three consecutive years.
b. 8 Hour: To attain this standard, the three-year average of the fourth-highest daily maximum 8-hour average of continuous ambient air monitoring data over each year must not exceed 0.08 ppm.

Coarse Particulate Matter:
c. 24 Hour: To attain this standard, the 99th percentile of the distribution of the 24-hour concentrations for a period of one year, averaged over three years, must not exceed 150 µg/m^3 at each monitor within an area.
d. Annual: To attain this standard, the arithmetic average of the 24-hour samples for a period of one year, averaged over three consecutive years, must not exceed 50 µg/m^3.

Fine Particulate Matter:
e. 24 Hour: To attain this standard, the 98th percentile of the distribution of the 24-hour concentrations for a period of one year, averaged over three years, must not exceed 65 µm/gm^3 at each monitor within an area.
f. Annual: To attain this standard, the three-year average of the annual arithmetic mean of the 24-hour concentrations from single or multiple population oriented monitors must not exceed 15.0 µg/m^3.

Sulfur Dioxide:
g. 24 Hour: Average.
h. Annual: Arithmetic mean.

Lead:
i. Quarterly: Average.

although special studies have measured pollutants in the central portion (Tuweep) and just west of the park at Meadview in Lake Mead National Recreation Area. Measured levels of PM on the Hualapai reservation on the South Rim are well below national standards. SO_2 and NO_2 data are now being collected there, but no definitive health-related effects are known yet (Havatone, pers. comm. 2004).

While air quality in the Grand Canyon area is generally good, pollution levels are high enough to create haze that often reduces visibility. Most of this visibility degradation is attributable to a widespread, homogeneous haze from a multitude of sources (US EPA 1999) that is transported to the area predominantly from industrial and metropolitan sources in southern Arizona, Nevada, California, and northern Mexico (EA Engineering, Science, and Technology 2002). These sources are outside the park's and the tribe's direct influence and control, and they are the

subject of a collaborative pollution-reduction effort by western states, tribes, and the federal government.

Unlike other pollutants regulated under the national standards, ozone is not emitted directly into the atmosphere. Rather, it forms through a series of chemical reactions between NO_x and volatile organic compounds (VOCs) in the presence of sunlight. Consequently, levels of ozone are highest during the summer (when solar radiation peaks) and tend to rise during the day and fall at night. This pattern has been observed in the western Grand Canyon (closer to pollution sources), but daily "swings" in ozone are not observed near Grand Canyon Village. The stability and timing of ozone levels in the eastern Grand Canyon indicate that local production of ozone (expected during daylight) is at least augmented, if not dominated, by transport of ozone from upwind source areas throughout the day and night.

Estimated emissions within Grand Canyon National Park (including Grand Canyon Airport, which is near the park) account for a generally small fraction of total estimated emissions for both Coconino and Mohave Counties. A microinventory of these park emissions was conducted for 2000 (EA Engineering, Science, and Technology 2002), but did not include emissions from river activities except motorized rafts above Diamond Creek. For this environmental impact statement, the 2000 emissions data have been supplemented with river activity-related data developed for each alternative. The resulting contribution from all park pollution sources to emissions for Coconino and Mohave Counties is shown in Table 3-2.

TABLE 3-2: GRAND CANYON AND COUNTY EMISSIONS OF AIR POLLUTANTS
(tons/year)

	SO_2	NO_X	CO	PM_{10}	VOC	Total
Grand Canyon Emissions (2000)	3.19	106.27	2579.84	208.04	232.94	3,130.27
Coconino and Mohave County Emissions (NEI)	1,934	35,854	104,599	2,209	18,074	162,670
Grand Canyon Contribution	0.16%	0.30%	2.47%	9.42%	1.29%	1.92%

Road vehicles, wildland fires, and prescribed burning are the chief sources of emissions in the park overall. Within the river corridor, sources of pollutants include motorized boats, helicopters, and campfires in the winter that can attribute to localized haze due to temperature inversions.

LEES FERRY TO DIAMOND CREEK

The primary sources of emissions related to recreational use of the Colorado River above Diamond Creek (RM 225) are motorized rafts and commercial use of helicopters at Whitmore for exchanging passengers.

Helicopter Exchanges at Whitmore

Many of the commercial companies coming down river from Lees Ferry use the helicopter exchange point at Whitmore (RM 187) to allow their passengers to exit the river by means of helicopter and end their trip at Bar 10 Ranch on the adjacent North Rim. Helicopter flights at

Whitmore in 2002 were estimated at 1,600 flights during the commercial river season, and approximately 3,500 people were transported into the canyon and 6,800 persons out.

Criteria Pollutants

The use of the river within the Grand Canyon for recreational activities is known to create air pollutant emissions that could affect air quality resources. For each alternative, emissions from motorized watercraft, aircraft, and campfires were considered. Estimated emissions for CO, NO_x, PM_{10}, SO_2, and VOCs for the entire canyon are summarized in Table 3-3. Individual source types generally contribute less than 5% of the park's emissions for a given pollutant. From Lees Ferry to Diamond Creek it is estimated that outboard motors generate 10% of the total CO produced in the park, the greatest contribution of a single source to a single pollutant along the Colorado River corridor. Current river operations between Lees Ferry and Diamond Creek produce about 10% of the park's non-fire emissions of CO, 3% of NO_x, less than 1% of PM_{10}, 4% of SO_2, and 3% of VOCs.

Acid Deposition on Aquatics and Soils

Deposition of total nitrogen and sulfur from emissions of NO_x and SO_2 has the potential for acidification on aquatic areas, as well as soils. Major sources of NO_x and SO_2 emissions are required to assess the impacts of the emissions on these resources. The emissions from the river operations above Diamond Creek are well below the 100-tons-per-year threshold for such assessment (0.1 ton SO_2 and 3 tons NO_x). In addition, the NPS Air Resources Division has determined that there is a sufficient buffer in the Grand Canyon region to neutralize any potential

TABLE 3-3: EMISSIONS ASSOCIATED WITH RECREATIONAL USE OF THE COLORADO RIVER IN GRAND CANYON

	SO_x		NO_x		CO		PM		VOC	
	tons	%	tons	%	tons	%	tons	%	tons	%
Total estimated park emissions	3.25	100.00%	106.70	100.00%	980.73	100.00%	59.24	100.00%	195.35	100.00%
Campfire emissions	0.00	0.09%	0.02	0.02%	1.84	0.19%	0.25	0.42%	1.67	0.85%
•Above Diamond Creek	0.00	0.06%	0.01	0.01%	1.21	0.12%	0.17	0.28%	1.10	0.56%
•Below Diamond Creek	0.00	0.03%	0.01	0.01%	0.63	0.06%	0.09	0.14%	0.57	0.29%
Aircraft emissions	0.53	16.16%	4.25	3.98%	24.48	2.50%	0.03	0.05%	3.62	1.85%
•Quartermaster passenger exchanges	0.40	12.17%	3.27	3.07%	23.09	2.35%	0	0.00%	3.41	1.75%
•Whitmore passenger exchanges	0.13	4.00%	0.98	0.92%	1.39	0.14%	0.03	0.05%	0.21	0.11%
Watercraft emissions	0.0	0.00%	10.66	9.99%	498.10	50.79%	0.07	0.12%	22.02	11.27%
•Commercial outboards LF-DC	0.0	0.00%	2.06	1.93%	95.96	9.78%	0.01	0.02%	4.24	2.17%
•Private outboards LF-DC	0.0	0.00%	0.06	0.06%	2.72	0.28%	0	0.00%	0.12	0.06%
•Lower Gorge commercial	0.0	0.00%	1.42	1.33%	65.96	6.73%	0.01	0.02%	2.91	1.49%
•Lower Gorge noncommercial	0.0	0.00%	0.06	0.06%	3.09	0.32%	0	0.00%	0.14	0.07%
•HRR day trips	0.0	0.00%	1.10	1.03%	51.54	5.25%	0	0.00%	2.28	1.17%
•HRR overnight trips	0.0	0.00%	1.11	1.04%	51.53	5.25%	0	0.00%	2.28	1.17%
•Pontoon tours near Quartermaster	0.0	0.00%	0.19	0.18%	9.08	0.93%	0	0.00%	0.40	0.21%
•Jetboat pick-ups	0.0	0.00%	13.30	12.46%	2.04	0.21%	0.40	0.67%	0.44	0.23%
Lees Ferry — Diamond Creek emissions	0.13	4.06%	3.11	2.92%	101.28	10.33%	0.21	0.35%	5.67	2.90%
Lower Gorge emissions	0.40	12.20%	20.45	19.17%	206.95	21.10%	0.49	0.83%	12.43	6.36%
Total River-associated emissions	0.53	16.25%	23.56	22.08%	308.24	31.43%	0.70	1.18%	18.10	9.27%

effect from acidification from these compounds on both soils and aquatic regions (Binkley et al. 1997).

Ozone Impacts on Vegetation

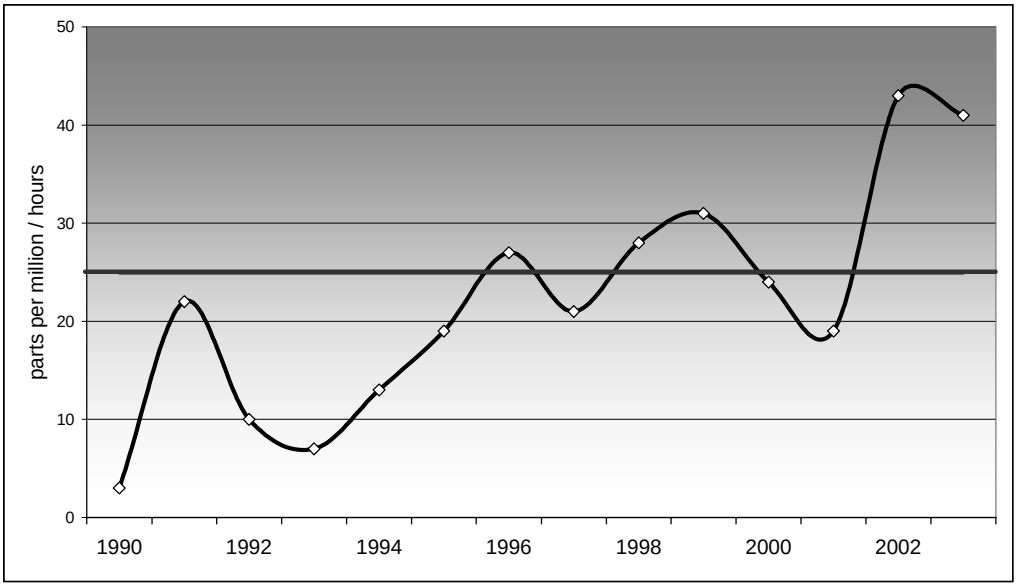
Ozone has been known to affect several plant species that occur within the Grand Canyon National Park and the Hualapai Reservation. Major sources of NO_x and VOC emissions (precursors to ozone formation) are required to assess the impacts of the emissions on these resources. Emissions of these pollutants from the river operations above Diamond Creek total 9 tons per year (3 tons NO_x and 6 tons VOC), 3% of the total park emissions of these pollutants and well below the 100-tons-per-year threshold for major source assessment.

The National Park Service determined that the sum of daytime ozone concentrations greater than 60 ppm during the highest three months of the growing season (referred to as SUM06) would have a major impact if the value exceeded 25 ppm-hrs. The SUM06 values measured in the park have exceeded the 25 ppm-hrs in 1996, 1998, 1999, 2002 and 2003 (Figure 3-2; GRCA air quality resource files). The park genotypes for ozone-sensitive plant species have not been tested under controlled conditions for sensitivity. Although no signs of injury from air pollution have been reported forponderosa pine or lichens in the park, these observations are based on limited studies performed in 1992 and 1993 (Binkley et al. 1997). SUM06 values exceeding 25 ppm-hrs were not observed until 1996, and widescale systematic studies have not been conducted.

Visibility

Concerns about visibility degradation in the Lees Ferry reach generally parallel those outlined above. Although vistas are not as extensive within the canyon as they on the rims, poor visibility

FIGURE 3-2: ANNUAL OZONE EXPOSURE — GRAND CANYON NATIONAL PARK



is still readily apparent in muted colors and loss of texture inside the canyon itself. Especially in more open sections like Furnace Flats and Granite Park, views from the river include long stretches of the canyon rim and long views down canyon. Although colored gases can reduce visibility, nearly all haze within the canyon is the result of fine particles (PM_{10} and especially $PM_{2.5}$) suspended in the atmosphere. Poor visibility is generally the result of sources outside the park. There is little direct emission of PM related to river recreation in the Lees Ferry reach (0.2 ton, 0.4% of park totals). Other pollutants, including NO_x, SO_2, and VOCs, can reach in the atmosphere to form haze-causing particles. However, this transformation takes time, allowing the relatively low emissions from river use to disperse and leave the canyon before particles form. Occasionally, localized visible plumes may form (especially under calm, winter conditions) from campfires or engine exhaust. Such plumes generally disperse quickly (within minutes to hours).

DIAMOND CREEK TO LAKE MEAD

Air quality of the Lower Gorge is somewhat different than that from Lees Ferry to Diamond Creek. Monitoring conducted by the National Park Service in 2003 found ozone levels at Meadview (outside the mouth of Grand Canyon) actually exceeding the EPA 8-hour standard (although three years of such concentrations would be needed to violate the national standard) (results located at <http://www.nature.nps.gov/air/monitoirng/exceed.htm>). Ozone levels at Tuweep (central Grand Canyon) exhibited a dramatic diurnal variation, possibly resulting from an up-canyon wind in the day drawing in pollution from the west and down-canyon wind at night bringing relatively clean air from the Arizona Strip.

The Lower Gorge also experiences a greater influence from urban areas, as evidenced by a study in the late 1980s (Miller et al. 1990) in which effects of air quality of the five-day workweek and two-day weekend pattern of the Los Angeles basin was seen as far east as Meadview, but not in Grand Canyon Village. In an attempt to explain the urban pattern (in this case, focusing on Las Vegas), the Grand Canyon Visibility Transport Commission was not able to accurately model transport to Grand Canyon from Las Vegas due to computer model limitations. However, a conceptual model suggested nocturnal drainage to Lake Mead basins, then daytime ventilation, assisted by solar heating on the Grand Wash Cliffs, "pumping" these pollutants onto the plateau during the day (Holmes, pers. comm. 1996).

Air quality in adjacent regions of Nevada is generally much worse than conditions monitored to the east near Grand Canyon Village. Clark County (including Las Vegas) has failed to meet the national ambient air quality standards for CO, PM_{10}, and ozone (although the county requested deferral of its ozone nonattainment designation until September 2004). Even though the county is a nonattainment area for CO, trends over the last decade have improved, with no violations of the standard from 2001 to 2003. High CO concentrations are generally confined to large urban areas, diluting and depositing rapidly downwind (see EPA 2000). In the absence of monitoring data from western Grand Canyon, elevated CO levels are possible but unquantifiable. A connection between Clark County ozone levels and expected levels in Grand Canyon is more clearly defined by monitoring at Meadview (discussed above). In this case, it does appear likely that ozone levels in Clark County strongly influence those in the western Grand Canyon. Until more data are available, the relationship between PM concentrations in Clark County and the western Grand Canyon will remain somewhat vague. However, meteorological conditions and various

special studies (e.g., Project MOHAVE) show pollutants reaching the Grand Wash Cliffs from the west.

Recreational use of the Colorado River changes below Diamond Creek. In addition to private and commercial river trips (including those operated by HRR), emissions are generated by four additional sources: (1) helicopter traffic near RM 262; (2) pontoon boats operated near RM 262 for flat-water excursions; (3) large jetboats that travel upriver as far as Separation Canyon (RM 240) to pick up river trip passengers for a high-speed shuttle to Lake Mead; and (4) noncommercial upriver motor boat traffic from Lake Mead. Passenger exchanges for raft trips and pontoon tours occur near Quartermaster. Based on use in July, it is estimated that as many as 600 to 800 helicopter flights a week land and take off on approximately 15 helipads near RM 262 (Mengel, pers. comm. 2003a). The majority of these flights are Hualapai land use tours, with up to 37% associated with pontoon boat rides and the remainder used to transport HRR passengers out of the canyon. This mix of river recreation results in higher emissions from Lower Gorge activities than from upstream recreational uses.

Based on current information, ambient air pollutant concentrations in the Lower Gorge appear to be higher than from Lees Ferry to Diamond Creek, probably as a result of the proximity to urban and utility source areas. This means that emissions in the western canyon may be a smaller percentage of the ambient load, but that ambient load may already be at levels worthy of concern.

Criteria Pollutants

Recreational activities on the Colorado River within the Lower Gorge related to motorized rafts, jetboats, helicopters and campfires are known to create air pollutant emissions that could affect air quality resources. Estimated emissions for CO, NO_x, PM_{10}, SO_2, and VOCs for the entire canyon are summarized in Table 3-3. Generally, specific craft types produce less than 5% of the park's total emissions of a given pollutant. Helicopter traffic near Quartermaster produces 12% of the park's total emissions of sulfur dioxide. Current total emissions from Lower Gorge watercraft and helicopters account for 21% of park non-fire emissions of CO, 19% of NO_x, 1% of PM_{10}, 12% of SO_2, and 6% of VOCs.

The National Park Service does not routinely monitor criteria pollutants in the Lower Gorge. As previously discussed. A special study in 2003 recorded summer ozone concentrations at Meadview, west of the park in Lake Mead National Recreation Area. In 2003 Arizona began particulate monitoring at Meadview, and the Hualapai tribe monitors PM, SO_2, and NO_2 on their reservation. However, long-term trends like those available in the eastern Grand Canyon are not yet available.

Acid Deposition on Aquatics and Soils

Deposition of total nitrogen and sulfur from emissions of NO_x and SO_2 has the potential to acidify aquatic areas, as well as soils. Major sources of NO_x and SO_2 emissions are required to assess the impacts of the emissions on these resources. The emissions from the river operations below Diamond Creek are well below the 100-tons-per-year threshold for such assessment (0.4 ton SO_2

and 20 tons NO_x). As in the Lees Ferry to Diamond Creek reach, soils should be adequately buffered.

Ozone Impacts on Vegetation

Emissions of NO_x and VOCs (precursors to ozone formation) from the river operations are estimated to total 34 tons per year (20 tons NO_x and 12 tons VOC). This amounts to 11% of the total park emissions of these pollutants, which is well below the 100-tons-per-year threshold for major source assessment.

There is insufficient data to calculate SUM06 values for the Lower Gorge. However, the initial results of monitoring at Meadview, and the proximity of high ozone levels in the Las Vegas metropolitan area to the west, suggest ozone exposures in the Lower Gorge may be even higher than those measured near Grand Canyon Village.

Visibility

Concerns about visibility degradation in the Lower Gorge generally parallel those outlined for the upper stretch of river. Although vistas are not as extensive within the canyon as they on the rims, poor visibility is still readily apparent in muted colors and loss of texture inside the canyon itself. Especially in more open sections, views from the river include long views down canyon. Although colored gases can reduce visibility, nearly all haze within Grand Canyon is the result of fine particles (PM_{10} and especially $PM_{2.5}$) suspended in the atmosphere. Poor visibility in the canyon is generally caused by sources outside the park, particularly because of the Lower Gorge's proximity to large metropolitan areas and utilities. There is little direct emission of PM related to river recreation in the Lower Gorge (0.5 ton, 1% of park totals). Other pollutants, including NO_x, SO_2 and VOCs, can reach the atmosphere to form haze-causing particles. However, this transformation takes time, allowing the relatively low emissions from river use to disperse and leave the canyon before particles form. Occasionally, localized visible plumes may form (especially under calm, winter conditions) from campfires or engine exhaust. Such plumes generally disperse quickly (within minutes to hours).

NATURAL SOUNDSCAPE

In accordance with NPS policy and *Director's Order #47: Sound Preservation and Noise Management,* the National Park Service is to preserve to the greatest extent possible the natural soundscapes of the park, which exist in the absence of any human produced noise. The natural soundscape is an aggregate of all natural sounds that occur in parks, together with the physical capacity for transmitting natural sounds. Natural sounds occur within and beyond the range of sound that humans can perceive, and are transmitted through air, water, and solid materials. Natural sounds are considered an inherent component of the scenery, natural and historic properties, and wildlands and proposed wilderness that constitute the bulk of the park (94%). Natural sound is vital to the visitor experience at the park and can provide valuable indicators of the health and "naturalness" of the ecosystems found here.

The components of soundscape along the river corridor are made up of natural sounds like flowing water, wind, storm activity, wildlife activity, other natural sound generation (rock slides, fire, etc..), and human-induced noise (motorized recreation, aircraft, human vocalization, electronics, etc.). Man-made or human sounds is the ambient sounds attributable to human activity, both near and far, and heard as a composite or individually. Human-made noise is defined in DO #47 as "an unwanted or undesired sound, often unpleasant in quality, intensity, or repetition, that adversely affects the natural soundscape." The National Park Service is tasked to restore degraded soundscapes to the natural condition wherever possible, and to protect natural soundscapes from degradation due to noise. Human noise sources within the river corridor are motorized watercraft, vehicle and tour bus noise from roads at launch/retrieval sites, camp activities, and aircraft overflights, with aircraft noise being the dominant noise source most often noticed by visitors.

Noise can distract visitors from park resources, purposes, and values, affect traditional cultural properties and the tranquillity of historic park settings, and affect wildlife use patterns and daily life activities. Grand Canyon's natural soundscape is considered a disappearing resource that requires restoration, protection, and preservation as a means of preventing natural sounds from being masked or obscured by the wide variety of human caused noise impacts. The soundscape is but one dimension of the complex problem of achieving a balance between resource preservation and recreational use. Preserving the natural soundscape for the enjoyment of future generations and preventing impairment of park resources is a major component of the NPS mission.

NATURAL AMBIENT SOUND LEVELS

Natural ambient sound levels of the park along the river corridor vary considerably from location to location, or from time to time at any given site. Best available science has been used to define the background ambient sound levels in representative locations and vegetation types along the river corridor, and to account for additions of human-caused noise that affect the ambient soundscape in these areas. In areas not affected by human-caused noise, variations in natural ambient sound levels are generally due to wind, water, and wildlife, and they are affected by the vegetation type and topography. During the late summer and early fall of 1992, the National Park Service contracted with Harris Miller Miller and Hansen, Inc. (1993) to conduct a study of ambient

TABLE 3-4: SUMMARY OF NPS AMBIENT SOUND LEVEL MEASUREMENT DATA SELECTED LOCATIONS IN GRAND CANYON NATIONAL PARK, AUGUST–SEPTEMBER 1992

Location	Typical Measured Soundscape Ambient Level (dBA)	Natural Ambient Sound Level, dBA*		
		L_{MAX}	L_{90}	Source of Noise
Lipan Point**	37	49	27–30	East Rim Drive
Bright Angel Point**	27	38	21	North Rim, near lodge
Point Sublime**	23	38	12	-
96 Mile Camp	39–46	46	36–38	Water, wind
Deer Creek Falls	45–49	49	43–44	Water
Whitmore Rapids	36–48	48	34–39	Water, wind, wildlife
Toroweap Overlook[4]	22–24	27	11–25	Wind, wildlife
Separation Canyon	21–28	28	13–22	Water, wildlife
Burnt Springs Canyon	19–26	26	19–24	Wildlife

SOURCE (except where noted): Harris Miller Miller and Hansen, Inc. (1993)

* Natural sound level in the presence of human noise from aircraft or other human-caused noise sources.

** NPS 1995 a, 139.

sound levels in Grand Canyon, using A-weighted sampling. For purposes of the study, natural ambient sound levels in Table 3-4 were determined in the presence of audible human-caused noise including aircraft overflights. Typical sound level measurements consisted of a series of 10- to 20-minute sample intervals at 23 different sites, equaling a total measurement period of over 300 hours. Not surprisingly, the natural soundscape along the Colorado River is directly influenced by the presence of fast-moving water. Applicable natural ambient sound levels at selected sites along the Colorado River corridor and on the canyon rim are shown in Table 3-4. For comparison purposes, dBA values for commonly experienced sounds are given in Table 3-5.

TABLE 3-5: COMMONLY EXPERIENCED SOUNDS

Reference Sound	dBA Level
Whispering at 5 feet	20 dBA
Quiet residential area	40 dBA
Normal conversation	60 dBA
Helicopter landing at 200 feet	80 dBA
Steam train whistle at 100 feet	90–100 dBA
Jet aircraft takeoff at 500 feet	100 dBA

SOURCE: League for the Hard of Hearing, n.d.

AIRCRAFT OVERFLIGHTS

Visitor experiences in the entire park are affected by aircraft noise impacts from a range of overflight sources, including high-altitude commercial jet traffic, military training activity, general aviation use, NPS administrative operations (emergency and facility maintenance), and commercial air tours. Impacts from these overflights, along with river running activity noise, are analyzed in the impact analysis in Chapter 4. Natural quiet in Grand Canyon National Park has been "significantly adversely" affected by aircraft noise for a number of years, as specifically noted in the National Parks Overflights Act of 1987 (16 U.S.C. 1a-1). The National Park Service is working with the Federal Aviation Administration to reduce aircraft noise levels and associated impacts and to substantially restore natural quiet by 2006. The current percentage of the park affected by aircraft noise has not yet been computed.

When characterizing the natural soundscape environment at Grand Canyon National Park, early predictive models determined that 19%–40% of the park area was "free" from overflight noise for three-quarters to all day. Aircraft noise data are currently being gathered to update noise simulation model runs, which will more accurately predict the percentage of the park that is actually free of aircraft noise and provide a scientifically based estimate on the degree of progress in restoring natural quiet at Grand Canyon. Early indications of progress on this effort are expected to be available in late 2004. The Federal Aviation Administration is also working on proposing a final rule on the standard to be used for defining "quiet technology," which will further address the aircraft noise issue at Grand Canyon.

CAVE RESOURCES

The Federal Cave Resources Protection Act of 1988 defines the term cave as

> Any naturally occurring void, cavity, recess, or system of interconnected passages beneath the surface of the earth or within a cliff or ledge, including any cave resource therein, and which is large enough to permit a person to enter, whether the entrance is excavated or naturally formed. Such term shall include any natural pit, sinkhole, or other feature that is an extension of a cave entrance or which is an integral part of the cave.

For management purposes, Grand Canyon National Park extends this definition to include natural features only if they contain a twilight zone and a zone of perpetual darkness (therefore, Redwall Cavern is not defined as a cave). In addition, human-made features (i.e., mine works) that comprise a twilight zone and a zone of perpetual darkness may be managed as caves per initial recommendations, except more latitude is given for mitigating hazards to human health and safety (NPS 2003a, 2003b).

The term "cave resource" includes any material or substance occurring naturally in caves on federal lands, such as mineral formations (speleogens and speleothems), paleontological deposits (including quaternary deposits), and plant and animal life (Federal Cave Resources Protection Act of 1988). Grand Canyon National Park has extended this definition through initial recommendations in the "Draft Cave and Karst Management Plan" (NPS 2003a) to include intrinsic historic and/or archeological resources contained within, or associated with, cave and karst features, as discussed below:

- Within Grand Canyon caves, mineral formations such as stalactites and stalagmites (called speleothems) take many forms, develop very slowly, are often fragile, and are irreplaceable if damaged or destroyed. Unconsolidated floor deposits in dry caves are unique regionally, if not globally, and have great scientific and aesthetic value. These deposits have been used to reconstruct past climatic conditions and may yet yield valuable paleo-hydrological information.
- Caves in Grand Canyon are integral to the hydrologic setting and the source of many spectacular waterfalls. Caves are important pathways for unique water resources. The park's water supply comes from Roaring Springs, which emanates from a cave below the North Rim.
- Paleontological resources discovered in Grand Canyon caves include the bones and other remains of Pleistocene-age animal species, some of which are extinct and some which still exist in the area. Pollen, seeds, and other plant parts, as well as the bones and teeth of small animals encased in animal dung and packrat middens (urine-cemented nest debris) provide invaluable evidence about ancient environments in the region (Euler 1984; Emslie 1988). Other paleontological resources found outside caves include lizard tracks, nautoloids, and other fossil resources primarily in limestone and sandstone deposits.
- Archeological resources include small animal effigies (split-twig figurines), grass bundles, human-modified twigs, and small rock cairns dating from the Archaic period, some 2,000 to 4,000 years ago (Schroedl 1977; Emslie et al. 1995). Prehistoric and protohistoric artifacts left by ancestral Puebloans, the Cohonina, and the ancestors of

modern tribes have been found in caves as well. Historic artifacts include, but are not limited to, excavation equipment left by researchers from the 1940s (Moffitt 2002).

- Grand Canyon caves also provide habitat for wildlife species, including cave invertebrates, raptors, small ground-dwelling mammals, and several species of roosting and breeding bats, some of which are considered federal or state species of concern (see "Endangered, Threatened, and Sensitive Species") (Emslie 1988; Quinn and Petterson 1997). The documented caves in Grand Canyon are located in the natural area and provide relatively rare and unique nesting and roosting opportunities for California condors and breeding bats. As evidenced by their bones and the fossil remains of their prey, California condors (a federal endangered species) used Grand Canyon caves for thousands of years before being extirpated from the region (Emslie 1987). Reintroduced in 1996, condors are now occupying the same caves that members of their species used prehistorically and historically for nesting (Osborn 2002). Caves are used by condors for hatching their young, which begins in February, and birds hatched in May could remain in the nest through December, making them susceptible to impacts essentially throughout the entire year (February to December). Caves are used by Townsend's big-eared bat young, which are born in May and early June and remain in the nursing colony for two months, making them susceptible to impacts from May to about August.

In addition to the Federal Cave Resources Protection Act of 1988, the Archeological Resources Protection Act of 1979, the National Parks Omnibus Management Act of 1998, and the Endangered Species Act of all provide additional levels of protection for cave resources.

All caves within Grand Canyon National Park are restricted except Cave of the Domes off Horseshoe Mesa. Entry is limited to visitors with valid permits. Stanton's Cave and Rampart Cave have been gated to prevent unauthorized access by humans but still allow access for bats, small mammals, and invertebrates.

LEES FERRY TO DIAMOND CREEK

More than 300 caves have been documented within Grand Canyon, predominantly in the Redwall and Muav limestone formations, which are at or near river level in parts of upper, middle, and lower canyon. Several caves are accessible from the river and are thus vulnerable to impacts from visitation by river runners.

The most well-known cave in this area is Stanton's Cave. Named for Robert Brewster Stanton, it is located at RM 31 (right bank) and was the site of intensive archeological and paleontological research in the 1960s and 1980s (Euler et. al. 1984). Over 100 split-twig figurines were found during the initial excavations, and bones of extinct animals, mainly condor bones and Harrington mountain goats, were recovered. Evidence of Paleo-flooding was documented from driftwood deposited in the cave some 43,000 years ago.

In addition to the archeological and paleontological resources, the Townsend's big-eared bat (a federal species of concern) occupies the cave. A bat-friendly gate was installed to protect the species from human incursions into the cave while allowing free access for the bats.

Numerous caves occur in the Redwall limestone cliffs in the Nankoweap area. Many of these caves hold significant archeological remains and have been the subject of vandalism (inadvertent and deliberate) from visitors accessing the area from the Colorado River.

DIAMOND CREEK TO LAKE MEAD

Cave resources in the Lower Gorge are similar to those described above for the Lees Ferry reach, but because the limestone layers are closer to the river, they are more accessible to river runners. Bat guano and sloth dung are well documented in this area, prompting considerable exploration and exploitation of the resource in the 1950s.

Severe damage occurred in Rampart Cave in 1976 and 1977 when a human-caused fire destroyed the majority of a vast deposit of Pleistocene-age ground sloth and mountain goat dung, bones, hair, and other soft tissue, as well as the scientific information contained in the lost material. Rampart Cave has been gated to prevent unauthorized access by humans but to allow access for bats, other small mammals, and invertebrates. Additional cave sites in the area are known to contain the remains of the extinct ground sloth. The Muav caves were documented in the 1950s and have been the subject of limited scientific investigation.

VEGETATION

Table 3-6 lists common vegetative species in the Grand Canyon and their scientific names.

LEES FERRY TO DIAMOND CREEK

Vegetation along the Colorado River grows in three, roughly parallel bands within the inner canyon. From river level, extending upwards, these bands are (1) the new high-water zone along the shoreline but above the scour zone of fluctuating river flows; (2) the old high-water zone on older, pre-dam river terraces above the new high-water zone; and (3) desert scrub on the xeric talus slopes and cliffs above the old high-water zone (BOR 1995). The specific species found in each hydrologic zone are directly related to soil type, aspect, available moisture, topography, elevation and temperature (Natural Resources Conservation Service and NPS 2003).

Wetland and marsh vegetation grows intermittently along the river's edge in the new high-water zone and is most common in backwaters. It also occurs along tributaries in some of the side canyons and at numerous seeps and springs, which provide havens for these mesic plants.

Driftwood, used by river runners for firewood in the winter, is deposited during flood events and found along the mainstem shores and floating in the river and tributaries. River runner campsites generally are located on sandy beaches within the new high-water zone or between vegetation in new and old high-water zones.

TABLE 3-6: COMMON NATIVE VEGETATION SPECIES IN THE COLORADO RIVER CORRIDOR IN GRAND CANYON NATIONAL PARK

Common Name	Scientific Name	Common Name	Scientific Name
African mustard	*Brassica tournefortii*	McDougall's yellowtops	*Flaveria mcdougallii*
Agave	*Agave* spp.	Mormon tea	*Ephedra* spp.
Apache plume	*Fallugia paradoxa*	Navajo sedge	*C. specuicola*
Arrowweed	*Pluchea sericea*	Netleaf hackberry	*Celtis laevigata* var. *reticulata*
Barberry	*Mahonia fremontii*	Ocotillo	*Fouquieria splendens*
Bermuda grass	*Cynodon dactylon*	Pepperweed	*Lepidium* spp.
Boxelder	*Acer negundo*	Plantain	*Plantago* spp.
Broadleaved pepperweed	*Lepidium latifolium*	Poison ivy	*Toxicodendron radicans*
California barrel cactus	*Ferocactus cylindraceus* var. *cylindraceus*	Pricklypear cactus	*Opuntia* spp.
California redbud	*Cercis orbiculata*	Ravennagrass	*Saccharum ravennae*
Camelthorn	*Alhagi maurorum*	Red brome	*Bromus rubens*
Catclaw acacia	*Acacia greggii*	Ripgut brome	*Bromus rigidus*
Cattail.	*Typha domingensis*	Rushes	*Juncus* spp.
Cheatgrass	*B. tectorum*	Russian thistle	*Salsola tragus*
Cholla cactus	*Opuntia* spp.	Sawgrass	*Cladium californicum*
Common reed	*Phragmites australis*	Scouring rush	*Equisetum* sp.
Cotton cudweed	*Pseudognaphalium stramineum*	Scrub oak	*Quercus turbinella*
Cottonwood	*Populus fremontii*	Seep willow species	*Baccharis* spp.
Coyote willow	*Salix exigua*	Single-leaf ash	*Fraxinus anomala*
Creosote bush	*Larrea tridentata*	Sowthistles	*Sonchus asper, S. oleraceus*
Crimson monkeyflower	*Mimulus cardinalis*	Speedwell	*Veronica* spp.
Desert broom	*Baccharis sarothroides*	Tamarisk	*Tamarix ramosissima*
Giant hellebore	*Epipactis gigantea*	Thistle	*Cirsium* sp.
Golden columbine	*Aquilegia chrysantha*	Tree of heaven	*Ailanthus altissima*
Grapevines	*Vitis arizonica*	Velvet ash	*F. velutina*
Great bulrush	*Schoenoplectus tabernaemontani*	Water sedge	*Carex aquatilis*
Honey mesquite	*Prosopis glandulosa*	Watercress	*Rorippa nasturtium-aquaticum*
Hydrilla	*Hydrilla verticillata*	Weeping lovegrass	*Eragrostis curvula*
Joshua Tree	*Yucca brevifolia*	White brittlebush	*Encelia farinosa*
Kaibab sedge	*Carex curatorum*	Willows	*Salix* spp.
Maidenhair fern	*Adiantum capillus-veneris*		

New High-Water Zone

The new high-water zone (from the shoreline up to the discharge level, or approximately 125,000 cfs; BOR 1995) is populated by riparian vegetation that is often dense and has proliferated since scouring spring floods ceased after construction of Glen Canyon Dam. Once seasonal flows stabilized, riparian vegetation expanded into the old scour zone, initially increasing by one-half acre per mile per year and later slowing to one-quarter acre per mile per year (Pucherelli 1988). Vegetation in this zone is greatly influenced by river flow. For example, the extent of vegetation was greatly reduced by high flows in 1983, which peaked at over 92,000 cfs, but it recovered to pre-flood levels in subsequent years (Kearsley and Ayers 2001). Despite short-term fluctuations, the overall trend since completion of the dam has been the encroachment of new high-water zone vegetation onto sandy beaches used by river recreationists for camping and lunch stops (Kearsley, Schmidt, and Warren 1994; Webb, Melis, and Valdez 2002). Encroachment has been identified at 72 of the 148 commonly used sites currently being monitored by park staff (Brown and Jalbert 2003). Vegetation in this zone tends to recover relatively quickly from impacts.

Native Species. Native species represented in the new high-water zone include coyote willow, arrowweed, numerous species of seep willow, and many herbaceous species. Honey mesquite and other more xeric species have increasingly moved into this zone from the old high-water zone farther upslope. With the introduction of lower fluctuating flows in 1992, groundwater elevation dropped, resulting in a shift toward more upland species in most new high-water zone vegetation patch types (channel margin, sandbar-top, and water's edge) (Kearsley and Ayers 1996).

Exotic Species. Exotic species have been introduced to the corridor area and thrive in riparian areas along the new high-water zone. Tamarisk is the dominant woody riparian species, although species composition varies depending on geomorphic setting and antecedent flows (BOR 1995; Kearsley and Ayers 2001). Tamarisk was common throughout the reaches of the Colorado River drainage by the 1920s–1930s, with the fastest rate of invasion likely between 1935 and 1955 (Christensen 1962). Tamarisk quickly dominated the new high-water zone following dam construction; however, the trend toward increased sediment grain size in post-dam river deposits appears to be reducing germination success for this seed-bearing species and prompting a compositional shift toward clonal or rhizomatous species like willows, arrowweed, and exotic camelthorn (Stevens and Ayers 1993; GCMRC 1999). The most common exotic plant species found in the new high-water zone include the invasive ravennagrass, Russian thistle, Bermudagrass, ripgut brome, red brome, sowthistles, and cheatgrass. Additional exotic species include tree of heaven, broadleaved pepperweed, and weeping lovegrass (Stevens and Ayers 1993). The park's Science Center is monitoring the advance of African mustard, which is being transported downstream from Lees Ferry and upstream into the western end of the park from Lake Mead. The Hualapai Tribe has reported that hydrilla is moving upstream from Lake Mead.

Invasive exotic species are ecologically damaging because they crowd out native plants and threaten biodiversity, habitat quality, and natural ecosystem functions. These exotic plants can present problems for recreationists as well. Camelthorn, Russian thistle, and some of the grasses have spines or spikes that can make campsites and attraction sites very uncomfortable for river runners. Tamarisk can develop dense, nearly impenetrable thickets that overgrow campsites and limit access to attraction sites. However, tamarisk has some beneficial aspects as well, such as providing much appreciated shade for river runners and habitat for some insects, birds, reptiles and small mammals (Kearsley et al. 2003).

Old High-Water Zone

The old high-water zone is characterized by notably stable xeroriparian vegetation that was established just above the historic high waterline before construction of Glen Canyon Dam and since reworked by eolian processes (Turner and Karpiscak 1980). In upper Marble Canyon the dominant native plants include netleaf hackberry, California redbud, Apache plume, and scrub oak. In the remainder of the canyon, catclaw acacia and honey mesquite dominate. Perennial bunchgrasses and xerophytes (e.g., cacti) characterize the understory (Stevens and Ayers 1993). Some mature trees in this zone are continuing to grow despite the absence of historically high flows, but other plants are dying off (Stevens and Ayers 1993; GCMRC 1999). Species such as mesquite and hackberry are no longer recruiting in the old high-water zone, but they are becoming established in the new high-water zone where moisture is available for seed germination

(Anderson and Ruffner 1988; BOR 1995). Many plants of the old high-water zone are slow-growing and long-lived and require decades to recover from impacts (Webb 1996). Exotic invaders in the old high-water zone include Russian thistle and various brome grasses.

Upland / Desert Scrub

Desert grasses, forbs, cacti, and shrubs grow in low to moderate densities on talus slopes and cliffs above the old high-water zone and in side canyons. This community exhibits very slow biomass growth and low production of detritus and fewer insects (Walters et al. 2000). Characteristic species include Mormon tea, pepperweed, and pricklypear cactus in the upper canyon reaches (Carothers and Brown 1991). White brittlebush, creosote bush, ocotillo, agave, California barrel cactus, desert broom, and cholla cactus are characteristic of the lower canyon reaches. Like the old high-water zone, exotic invaders in this zone include various brome grasses. Two species that grow in the old high-water zone — the Kaibab agave and the Grand Canyon beavertail cactus — are discussed under "Endangered, Threatened, and Sensitive Species").

Wetlands

Fluvial marshes are wetlands associated with rivers that are frequently or continually inundated with water and are characterized by emergent soft-stemmed vegetation adapted to saturated soil conditions. Following construction of Glen Canyon Dam, fluvial marshes were established in backwaters (return-current channels) that were once reworked and scoured clean of vegetation by spring floods before the presence of the dam (Stevens and Waring 1985). Established marshes along the Colorado River are extremely dynamic and are continually altered by fluctuating water flows. High water releases from Glen Canyon Dam, which scour and deposit new sediments, have the most dramatic effect on marshes. Steady low flows can isolate marsh patches, causing them to dry out.

Estimates of total marsh area within the river corridor ranged from less than 1.24 acres in 1987 to 63.75 acres in 1992 (Stevens and Ayers 1993). An actual count of marshes in 1991 noted 253 wet marshes (cattail/reed and horsetail/Bermuda grass) and 850 dry marshes (horsetail/willow) between Lees Ferry and Lake Mead (Stevens et al. 1995). The experimental flood release in 1996 resulted in short-term burying of marshes by up to 6 feet of soil, but within six months, wetland patches appeared to have been restored to their pre-flood status (Kearsley and Ayers 1996). There have been no significant changes in vegetation patches along the river. In subsequent years (Kearsley and Ayers 2001; Kearsley et al. 2003).

While not large in area, marsh patches are important because they provide habitat for numerous faunal species. Birds, fish, and many wetland plants utilize the slower moving water in these marshes for nurseries and sanctuaries from the faster moving water of the mainstem (BOR 1995). Soils are rich in nutrients, and the slow currents allow fine-sediment particles to settle from suspension, which allows seed germination and seedling establishment. Vegetation in marshes typically consists of obligate wetland species such as rushes, great bulrush, water sedge, common reed, plantain, speedwell, cotton cudweed, cattail, and scouring rush. Exotic species include ravennagrass, tamarisk, and lovegrass.

Perennial tributaries, seeps, and springs also provide habitat for many of the obligate wetland species listed above. Spence (2002) identified four major types of habitat in side canyons: hanging garden backwalls, hanging garden colluvial slopes, wetlands dominated by water-loving plants like reeds and cattails, and riparian-like woodlands. Within these habitats, Spence (2002) identified four endemic plant species: Kaibab sedge, Navajo sedge, an undescribed thistle, and McDougall's yellowtops. Other wetland species found in side canyons include maidenhair fern, crimson monkeyflower, golden columbine, giant hellebore, sawgrass, watercress, and other shade- and moisture-loving plants (Carothers and Brown 1991). Vasey's Paradise is known for its lush growth of poison ivy and Havasu Creek for its grapevines. Several woody species rarely or never found in the main canyon find suitable conditions in watered side canyons. These species include boxelder, cottonwood, single-leaf ash, velvet ash, and barberry. Some species common in the main canyon, such as willow, tamarisk, and baccharis, colonize the sandy or cobbled substrates of the side canyons and occasionally form dense thickets.

Desert seeps and springs create important, sensitive habitats. They rank among the most productive and biologically diverse terrestrial ecosystems and commonly host 100- to 500-fold higher concentrations of species than the surrounding landscapes (Grand Canyon Wildlands Council 2003). Southwestern seeps and springs are often isolated islands of habitat that support an unusual proportion of relict and endemic species. Given their small scale and isolation, seep and spring habitats are particularly vulnerable to irreversible destruction. These keystone habitats contribute significantly to regional biodiversity. McDougall's yellowtops, which grows in some of these moist saline seeps, is discussed under "Endangered, Threatened, and Sensitive Species".

Driftwood

Woody material entrained in flooding tributaries enters the Colorado River as driftwood. A great percentage of driftwood originates from tributaries with large wooded watersheds. The amount of driftwood delivered to the river corridor depends on the frequency and magnitude of floods in those tributaries, so new supplies vary from year to year. Once in the river, driftwood floats downstream until it is deposited along the shore in areas of slow current. Piles of driftwood are commonly found in association with slow eddy currents at the base of rapids. Rapids in the Grand Canyon generally occur where the contents of debris flows have partially blocked the river at the mouths of steep side canyons. Consequently, driftwood tends to be plentiful in reaches that are characterized by numerous steep side canyons, which experience debris flows and resultant rapids. Driftwood on shore provides habitat for terrestrial invertebrates, amphibians, reptiles, and small mammals, and nesting material for some birds. Haden et al. (1999) suggest that driftwood may be an important habitat for macroinvertebrates and documented 20 taxa of several orders in that substrate.

DIAMOND CREEK TO LAKE MEAD

Vegetation in the Lower Gorge also occurs in three zones: (1) the new high-water zone, (2) the old high-water zone, and (3) upland or desert scrub, but the Mohave Desert influence is greater. Wetlands occur along the river in the form of marshes and in side canyon tributaries near seeps and springs, and driftwood can be found along the beaches near rapids or trapped in mud flats.

The cave-dwelling primrose is classified as a 3c species that grows on limestone walls in seeps and hanging gardens in the western end of Grand Canyon from Separation Canyon to Spencer Canyon (see "Endangered, Threatened, and Sensitive Species"). A beaver dam in Lost Creek has created a lake-like environment with associated wetland vegetation uncommon to the desert.

More than 1850 hectares of riparian and wetland habitats occur in the Lower Gorge, characterized by wet and dry marshes, Gooding's willow, arrowweed, grasslands, seep willow, coyote willow, and tamarisk (Christensen 2001). Tamarisk stands grow much denser, because the tributaries tend to be wider. Aerial surveys conducted by the Hualapai Tribe in 1994 show the dominant riparian species to be tamarisk, Gooding's willow, and coyote willow. The Kaibab suncup, a species of concern, grows on sandy or gravelly beaches, up side canyons that are rarely visited, and in dry washes on the Havasupai and Hualapai reservations (see "Endangered, Threatened, and Sensitive Species").

Vegetation in the old high-water zone is similar to that found within the lower sections of the Lees Ferry to Diamond Creek stretch. Common species include catclaw acacia, honey mesquite, perennial bunchgrasses, and xerophytes (e.g., cacti). Common desert scrub species in the lower gorge are white brittlebush, creosote bush, ocotillo, agave, California barrel cactus, and cholla cactus. The only Joshua tree forest in the Grand Canyon occurs in the Lower Gorge along the western rim.

TERRESTRIAL WILDLIFE

HABITAT

Variations in topography, vegetation structure, cover, moisture, and soil texture from Lees Ferry to Lake Mead and among the three hydrologic zones influence the types, abundance, and distribution of terrestrial wildlife communities.

- **Shoreline —** Along the shoreline wet and dry marsh vegetation such as cattails, bulrushes, horsetail, and giant reeds provide cover in the form of dense vegetation and an abundance of insect life, such as crickets, ground-dwelling spiders, carabid ground beetles, and plant-dwelling flies (Brantley et al. 2003).
- **New high-water zone —** In the moist sandy soil of the new high-water zone, riparian vegetation such as tamarisk, arrowweed, and willow grows. These plants, as well as driftwood and scattered rocks, provide cover for invertebrates, birds, small mammals, and reptiles. Bird species richness is greatest in this zone (Yard, pers. comm. 2003c). Marsh and new high-water zone vegetation provides forage for deer and bighorn sheep.
- **Old high-water zone —** More xeric plant species such as catclaw, mesquite, and cacti are found in the old high-water zone. Drier soils, extensive rock shelters, and older established plant communities provide a stable environment for terrestrial wildlife. This zone is rich in small mammals, reptiles, moths and plant-dwelling caterpillars and beetles (Carpenter 2003; Frey 2003; Brantley et al. 2003).

Ungulate species frequent all three zones on a seasonal basis.

LEES FERRY TO DIAMOND CREEK

Scientific names of species discussed in this section are given in Table 3-7.

Invertebrates

Invertebrates along the river corridor include scorpions, spiders, and several thousand species of insects from over 200 families (BOR 1995; Stevens 2002). They play an important role in terrestrial ecosystems by providing abundant supplies of food for other invertebrates, amphibians, reptiles, birds, and mammals. Terrestrial insect populations and diversity have appeared to increase since construction of Glen Canyon Dam due to the increase in riparian vegetation in the new high-water zone (Carothers and Brown 1991). Certain species of the orders Orthoptera, Coleoptera, Neuroptera, and Lepidoptera are closely tied to the presence of tamarisk and coyote willow, the most prevalent woody plants occurring in this zone. During a 2000 study of the river corridor, 199 terrestrial invertebrate taxa and 93 aquatic invertebrate taxa were recorded (Leslie 2000b). Four species of butterflies never previously reported from Grand Canyon were also found (hesperiid Arizona powdered-skipper, the megathymid piute agave skipper, the desert marble, and the desert elfin).

Aquatic insects like chironomids (midges), simuliids (blackflies), and ephemeropterans (mayflies) are aerial in their adult stages and may be encountered on beaches used for camping and lunch stops. An aging tadpole shrimp was recorded in an ephemeral pool in North Canyon (Leslie 2000).

Insects that annoy recreationists include flies, particularly biting flies, and harvester ants, which deliver a painful sting. Recreational activity in the river corridor appears to attract some terrestrial invertebrates to sites where organic waste accumulates. The abundance of harvester ants on beaches has been correlated to presence of small food particles, grease, and other types of organic litter left behind by campers (Carothers and Brown 1991; BOR 2002b). The distribution and size of flesh fly (Sarcophagidae) and blow fly (Calliphoridae) populations have also been correlated with campsite organic debris, including feces (BOR 2002b). In a recent survey of 46 camping beaches in Grand Canyon, human feces was recorded at 21 (45.7%) (Brown 2003).

TABLE 3-7: COMMON NATIVE WILDLIFE SPECIES IN THE COLORADO RIVER CORRIDOR IN GRAND CANYON NATIONAL PARK

Common Name	Scientific Name	Common Name	Scientific Name
Invertebrates		**Birds — Spring, Fall, and Winter Transients**	
Black witch moth	*Ascalapha Erebus odorata*	Great blue heron (also nests)	*Ardea herodias*
Tailless whipscorpion	*Paraphyrynus* spp	Snowy egret	*Egretta thula*
Salticid jumping spider	*Thiodina* spp.	American wigeon	*Anas americana*
Grand Canyon endemic tiger beetle	*Cicindela hemorrhagica arizonae*	Lesser scaup	*Aythya affinis*
Hesperiid Arizona powdered-skipper butterfly	*Systacea xampa*	Bufflehead	*B. albeola*
Megathymid piute agave skipper butterfly	*Agathymus alliae piute*	Common goldeneye	*B. clangula*
Desert marble butterfly	*Euchloe lotta*	Bald eagle	*Haliaeetus leucocephalus*
Desert elfin butterfly	*Callophrys fotis*	American coot	*Fulica americana*
Tadpole shrimp	*Triops longicaudatus*	Ruby-crowned kinglet	*Regulus calendula*

Common Name	Scientific Name	Common Name	Scientific Name
Amphibians		Dark-eyed junco	*Junco hyemalis*
Great Plains toad	*Bufo cognatus*	**Mammals**	
Red-spotted toad	*B. punctatus*	California myotis	*Myotis californicus*
Woodhouse's toad	*B. woodhousii*	Yuma myotis	*M. yumanensis*
Canyon treefrog	*Hyla arenicolor*	Western pipistrelle	*Pipistrellus hesperus*
Reptiles		Mexican free-tailed bat	*Tadarida brasiliensis*
Western whiptail lizard	*Cnemidophorus tigris*	Rock squirrel	*Spermophilus Variegatus*
Desert spiny lizard	*Sceloporus magister*	White-tailed antelope ground squirrel	*Ammospermophilus leucurus*
Side-blotched lizard	*Uta stansburiana*	Cliff chipmunk	*Tamias dorsalis*
Tree lizard	*Urosaurus ornatus*	Brush mouse	*Peromyscus boylii*
Western banded gecko	*Coleonyx variegates*	Canyon mouse	*P. crinitus*
Collard lizard	*Crotaphytus collaris*	Cactus mouse	*P. eremicus*
Common chuckwalla	*Sauromalus ater*	Deer mouse	*P. maniculatus*
Speckled rattlesnake	*Crotalus mitchellii*	Pinon mouse	*P. truei*
Black-tailed rattlesnake	*C. molossus*	Rock pocket mouse	*Chaetodipus intermedius*
Grand Canyon pink rattlesnake	*C. viridis abyssus*	Western harvest mouse	*Reithrodontomys megalotis*
Common kingsnake	*Lampropeltis getula*	White-throated woodrat	*Neotoma albigula*
Gila monster	*Heloderma suspectum suspectum*	Desert woodrat	*N. lepida*
Birds — Nesting Species (Riparian Vegetation)		Stephen's woodrat	*N. Stephensi*
Black-chinned hummingbird	*Archilochus alexandri*	Bushy-tailed woodrat	*N. cinerea*
Ash-throated flycatcher	*Myiarchus cinerascens*	Beaver	*Castor canadensis*
Bewick's wren	*Thryomanes bewickii*	Coyote	*Canis latrans*
Blue-gray gnatcatcher	*Polioptila caerulea*	Ringtail	*Bassariscus Astutus*
Bell's vireo	*Vireo bellii*	Gray fox	*Urocyon cinereoargenteus*
Lucy's warbler	*Vermivora luciae*	Mule deer	*Odocoileus hemionus*
Yellow warbler	*Dendroica petechia*	Bighorn sheep	*Ovis canadensis*
House finch	*Carpodacus mexicanus*	Mountain lion	*Felis concolor*
Birds — Nesting Species (Cliffs and/or Desert)		Bobcat	*Lynx rufus*
White-throated swift	*Aeronautes saxatalis*	Badger	*Taxidea taxus*
Black phoebe	*Sayornis nigricans*	**Fish**	
Say's phoebe	*S. saya*	Flannelmouth sucker	*Catostomus latipinnis*
Violet-green swallow	*Tachycineta thalassina*	Bluehead sucker	*Catostomus discobolus*
Canyon wren	*Catherpes mexicanus*	Speckled dace	*Rhinichthys osculus*
Birds — Nesting Species (Ground)			
Mallard	*Anas platyrhynchos*		
Common merganser	*Mergus merganser*		
Spotted sandpiper	*Actitis macularia*		

SOURCES: Carothers and Aitchison 1976; Butterfield et al. 1981; Miller et al. 1982; Brown, Carothers, and Johnson 1987; Carothers and Brown 1991; BOR 1995; Peterson and Spence 1997; Christensen 1998; Sogge, Felley, and Wotawa 2000; Kearsley et al. 2001; Yard, pers. comm. 2003c.
Nomenclature is according to the Integrated Taxonomic Information System (ITIS).

Recent surveys of arthropod abundance and species richness conducted by the Grand Canyon Monitoring and Research Center found that sites below the confluence with the Little Colorado River exhibited much higher values than sites above the confluence (Lightfoot, Brantley, and Cobb 2001). Depending on arthropod species, some are more abundant in the shoreline zone, and others in the old high-water zone (Brantley et al. 2003). Two invertebrate species, the cave pseudoscorpion and the Kanab ambersnail, are described in more detail under "Endangered, Threatened, and Sensitive Species."

Vertebrates

Amphibians. Amphibians are not well represented in the inner canyon due to generally arid surface conditions (NPS 1979c); however, toads such as the Woodhouse's and red-spotted toads are often reported by river recreationists near the river and in perennial tributaries. A hybrid species of these two toads also been described (Leslie and Holycross 2000). Tree frogs are rarely observed along the river, but are common in warmer tributaries. Leopard frogs, which were historically recorded both along the river and in perennial side canyon areas, are now uncommon in the Grand Canyon. With the completion of Glen Canyon Dam and the change from seasonally warm mainstem water to year-round temperatures below 50°F, leopard frog habitat became fragmented. Current population status of leopard frogs is unknown, and NPS personnel have initiated a Colorado Plateau-wide survey to assess numbers and distribution of both the northern leopard frog and relict leopard frog (see also "Endangered, Threatened, and Sensitive Species").

Reptiles. Sixteen species of reptiles have been identified along the Colorado River (Carpenter 2001). Reptiles commonly associated with the river corridor include Western whiptail lizards, tree lizards, desert spiny lizards, and Grand Canyon pink rattlesnakes. The Grand Canyon pink rattlesnake is endemic to the Grand Canyon and is the most commonly seen snake from Lees Ferry to below National Canyon (Carpenter 2003). Warren and Schwalbe (1988) found that specific sites within the new high-water zone, including the interface between the water and exposed sediment and open tamarisk sites, supported lizard densities equal to or higher than any other sites reported in the Southwest. Their studies also indicated that lizard densities were lowest in thick tamarisk sites within the new high-water zone. Carpenter (2003) found that snakes were more abundant in the old high-water zone, and several species of lizards were restricted to this zone.

Birds. Riparian habitats along the Colorado River in Grand Canyon National Park provide breeding habitat, migratory stopover sites, and wintering areas for birds throughout the year (Brown, Carothers, and Johnson 1987; Sogge et al. 2002). Over 350 species of birds have been recorded in the Grand Canyon region, approximately 250 of which are from the river corridor (Johnson 1991). Some species are year-round residents such as the canyon wren and the American dipper, but most are migrants that use the river seasonally for breeding or as a travel corridor, or they are from other canyon habitats and use the river corridor during non-breeding or migratory seasons.

At least 48 species of birds nest along the Colorado River in the park, primarily from April through June (BOR 1995). Numerous researchers have noted the importance of the riparian habitat along the Colorado River for neotropical migratory bird species (Brown, Carothers, and Johnson 1987; Drost 1996; Sogge et al. 2002). Nesting habitat includes ground cover near the river, riparian trees and shrubs in the new and old high-water zones, cliff walls, and desert habitats (Brown, Carothers, and Johnson 1987). Bird species characteristic of the new high-water zone include the yellow warbler, Lucy's warbler, Say's phoebe, and the black phoebe. The old high-water zone is characterized by the Ash-throated flycatcher, canyon wren, and rock wren.

Other species that breed in the canyon and are present through most of the summer include the song sparrow, house finch, and Bell's vireo (Yard, pers. comm. 2003c; Spence 2003). Recent studies have noted the expansion of breeding populations of the song sparrow and Bell's vireo

upriver from Lake Mead (Kearsley et al. 2003). These changes are possibly due to changes in vegetation and other habitat characteristics brought about by the operation of Glen Canyon Dam.

Mallards and common mergansers also breed in the park and build their nests on the ground. Numerous transient birds such as the great blue heron and snowy egret utilize the canyon's riparian habitats primarily during spring and fall migrations. Stevens et al. (1997) found that waterfowl were more abundant in winter than in the other three seasons and are particularly abundant in the upper reaches of the canyon between Lees Ferry and the confluence with the Little Colorado River. Birds that are considered endangered, threatened, or sensitive species (including the California brown pelican, California condor, bald eagle, American peregrine falcon, Mexican spotted owl, and southwestern willow flycatcher) are described more fully in "Endangered, Threatened, and Sensitive Species".

Bats. At least 22 species of bats have been documented in Grand Canyon (Leslie, pers. comm. 2003). All but one of these are insectivorous and may be attracted to the river corridor by the numerous insects associated with the river and riparian vegetation. Some roost in caves and crevices that abound in the inner canyon, while others are forest dwelling and use the riparian corridor for foraging. Common bat species are listed in Table 3-7. Uncommon to rare species occurring along the riparian corridor include the hoary bat, fringed myotis, red bat, Townsend's big-eared bat, spotted bat, and long-tongued bat (Butterfield et al. 1981; Leslie, pers. comm. 2003). The Mexican long-tongued bat is primarily nectarivorous and fugivorous and is the only phyllostomid species found in the park. More detailed descriptions of bat species listed as species of concern are given in the "Endangered, Threatened, and Sensitive Species."

During hibernation, bats are highly susceptible to disturbance, making hibernacula an important focus for management and protection efforts. For Mexican long-tongued bats that do not enter torpor, warm geothermally heated winter roosts in caves and mines are critical for their survival. In some situations metal gates can be installed to allow passage by bats while restricting access by humans. Such gates, when properly designed and installed (e.g., Stanton's Cave), have allowed populations to recover at many sites where humans entering caves have disturbed bat colonies.

Small Mammals. Within the riparian zone, rodents are the most common small mammals, with at least 14 species representing seven genera (Carothers and Aitchison 1976; Leslie, pers. comm. 2003). The deer mouse is the only rodent that depends directly on the riparian zone for its existence (BOR 1995). Small mammal abundance and richness is greatest in the old high-water zone, where steeper slopes, rock falls, and canyon wall crevices provide greater structure for wildlife habitat (Frey 2003). Common OHWZ species captured by Frey include the cactus mouse, brush mouse, desert woodrat, canyon mouse, rock pocket mouse, and white-throated woodrat. NPS surveys conducted in 2000 also include the pinon mouse, Western harvest mouse, and bushy-tailed woodrat as common (Leslie 2000). Woodrats provide forage for Mexican spotted owls. One of the rarest small mammal species in the canyon is the Ord's kangaroo rat (Leslie 2000; Frey 2003).

Historically, three furbearers were known to the Grand Canyon — muskrats, otters, and beavers. All are native inhabitants to Arizona, though none is considered numerous or well-known. Since the completion of the Glen Canyon Dam in 1963, muskrats have rarely been observed along the

river corridor. An inventory conducted in 2000 reported no signs of muskrats along 143 river bank miles (Breck and Kellett 2000); muskrats have likely been extirpated from the park.

The least known of these three mammals is the southwest river otter. The U. S. Fish and Wildlife Service is presently investigating its status because of its limited distribution, low numbers, and potentially threatened or endangered status in Arizona (Dubuc et al. 1990), and it is further described under "Endangered, Threatened, and Sensitive Species."

Beavers occur throughout the river corridor, from Glen Canyon Dam to the Grand Wash Cliffs, being most common where riparian vegetation is well developed. Beavers have probably been present in the Grand Canyon throughout the last 10,000 years (4,000 year-old bones were found in Stanton's Cave). Beaver populations within the Grand Canyon began to expand after the completion of Glen Canyon Dam (Carothers and Brown 1991), which is attributed to the cessation of spring floods and the post-dam development of extensive riparian vegetation. The inventory conducted in 2000 recorded beaver signs at 23 sites from RM 0.8 to RM 208.5 (Breck and Kellet 2000); five of these sites were identified as river runner campsites. NPS surveys during the same year indicate that beavers are evenly distributed along the river in suitable habitat (Leslie 2000). Examination of dens indicate a variety of preferred foods, including willow cuttings, tamarisk, mesquite, catclaw acacia, cottonwood, cattails and tuberous roots of aquatic and riparian plants (Leslie 1999; Leslie and Ward 2000). Coyote willow appears to be the staple food in Grand Canyon. Beaver also use the larger Gooding's willow. Gooding's willows at Buck farm and Saddle were cut by beaver in the mid 1980s, and Gooding's willows near Cardenas are interspersed with the old stumps felled by beaver.

Large Mammals. Large mammals found within the river corridor include several game species. Bighorn sheep are often seen by river runners when the sheep descend to the river to forage. Mule deer are common seasonally and can be seen browsing on riparian vegetation. NPS staff have documented the presence of mountain lions and bobcats feeding on these ungulates near the river. Feral burros, an introduced species that proliferated and roamed throughout the inner canyon, were largely eradicated in the 1970s. They are once again found in the park in low numbers in the west end (Leslie, pers. comm. 2003). Burros and trespass cattle are considered exotic species in the park and are removed whenever possible.

DIAMOND CREEK TO LAKE MEAD

Many of the species that occur above Diamond Creek also occur in the Lower Gorge. In addition to the terrestrial wildlife species discussed above, several other species that occur within the Grand Canyon National Park have only been observed or are more prevalent in the Lower Gorge.

Amphibians. In 1997 Larry Stevens found a decomposed leopard frog specimen in a Lower Gorge tributary; it was later identified as a relict leopard frog. This discovery was included in the petition to list the relict leopard frog as a candidate species on the Arizona list of threatened wildlife. An extant relict frog population was recently confirmed in this same side canyon, with the finding of relict frog sub-adults and egg masses (Drost, pers. comm. 2004). Hualapai

biologists also collected a desiccated relict frog specimen in a tributary on the Hualapai Reservation below Diamond Creek (Hualapai Department of Natural Resources, pers. comm.).

Reptiles. The only known population of Sonoran desert tortoise in the park occurs in the upland habitat in the Lower Gorge. In May 2004 biologists from Lake Mead and Grand Canyon discovered desert tortoise scat in the Lower Gorge (river right) that was possibly from a Mojave desert tortoise (Leslie, pers. comm. 2004a). The Mojave desert tortoise population was federally listed as threatened in 1990 (see "Endangered, Threatened, and Sensitive Species"). Gila monster habitat is also present in the Lower Gorge, and this species has been observed more often here than anywhere else in the park. The speckled rattlesnake is the most commonly observed snake from about Lava Canyon and below Diamond Creek, but blacktail rattlesnakes have been encountered from Stairway to Pearce (Leslie and Holycross 2003; Carpenter 2003).

PHOTO 3-1: YELLOW-BREASTED CHAT

Birds. Based on surveys in 2001 and 2002 (Christensen 2002), the most common bird species in the Lower Gorge include the yellow-breasted chat, Bell's vireo, song sparrow, yellow warbler, blue-gray gnatcatcher, Bewick's wren, and Lucy's warbler. Song sparrows appear to be increasing in the Lower Gorge (Christensen 2002), and extensive heron rookeries are also present. The Burnt Springs area contains excellent bird habitat and is the site of a yellow-billed cuckoo observation and three individual Yuma clapper rails (San Bernardino College, pers. comm. 2001). The Lower Gorge also contains a population of peregrine falcons in numbers and distribution similar to that observed in the Upper Canyon. In addition, a significant portion of proposed critical habitat for the southwestern willow flycatcher is found below RM 246. See "Endangered, Threatened, and Sensitive Species" for a more detailed description of these federally listed bird species.

Bats. Bat Cave is a summer maternity colony that varies in size from 50,000 to 500,000 Mexican free-tailed bats and a smaller number of over-wintering bats (Bat Conservation International 1998; Leslie and Peterson 1996). This population is likely the largest known population in Arizona and may be the largest population west of Texas. At one time the pre-guano mining population was thought to be as large as 20 million individuals.

Long-tongued bats are also common in the Lower Gorge, and half of those collected during surveys came from below Diamond Creek. A Pleistocene era vampire bat collection came from Rampart Cave located in the Lower Gorge.

Mammals. Most of the common mammal species also occur below RM 225. Mesocarnivore surveys conducted by Reed and Leslie in 2003 indicate that there tends to be a greater concentration of badgers in the Lower Gorge. The gray fox is another abundant mammal species (Reed and Leslie 2003), and coyotes are often seen feeding on vegetation, small mammals, and reptiles.

AQUATIC RESOURCES

LEES FERRY TO DIAMOND CREEK

Aquatic Habitat

Mainstem. As previously discussed, the aquatic ecosystem of the Colorado River in Grand Canyon National Park is strongly influenced by the presence and operation of Glen Canyon Dam, 15 miles upstream of the park boundary. How the river ecosystem has changed is highlighted in Table 3-8.

TABLE 3-8: CHARACTERISTICS OF THE COLORADO RIVER BEFORE AND AFTER GLEN CANYON DAM CONSTRUCTION

Characteristics before Dam Construction	Present Characteristics (after Dam Construction)
1. Muddy water from high sediment loads.	1. Generally clear water.
2. A food base dependent on tributary input of terrestrial vegetation and detritus.	2. A food base dependent on photosynthetically produced algae and macrophytes.
3. Seasonally varying temperatures ranging from freezing to 86°F (30°C).	3. Thermally constant dam releases ranging from 46°F to 50°F (8°C to 10°C).
4. High spring floods but stable flows for most of the year.	4. Daily variability in discharge (doubling of river volume) due to hydroelectric production.
5. Diverse aquatic insect assemblage supporting abundant native fish.	5. Depurate aquatic insect assemblage supporting an abundant alien fish community.

Source: Before dam construction — Haden et al. 2003; present characteristics (after dam construction) — Shannon 2001.

Tributaries and Springs. Tributary streams in the Grand Canyon can be depicted as either small, spring-derived, cool-water streams with high benthic biomass and species richness or watershed-derived, warm-water streams with low benthic biomass and species richness (Oberlin, Shannon, and Blinn 1999; Shannon 2001). All of these tributaries have a natural seasonal range of temperatures and discharge. For example, Bright Angel and Tapeats Creeks have a spring source, cooler range of temperatures, and support introduced, nonnative trout species. Watersheds such as the Paria River, Little Colorado River, Kanab Creek, and Havasu Creek have higher stream temperatures and support more native fish species. Tributaries also vary in other water quality parameters (see Appendix D).

Over 680 seeps and springs have been identified in Grand Canyon National Park, with more than 500 accessible from the river (Stevens 2003). While the ecology of these springs is only beginning to be described, they are recognized as vital hubs of biodiversity, especially for invertebrates, in this arid region (Thomas, Blinn, and Keim 1998). Spring-derived tributaries are key habitats in Grand Canyon — their ecological importance exceeds what would be expected given their drainage area, such as Roaring Springs, the source of Bright Angel Creek (Drost and Blinn 1997). Many species associated with springs in the Grand Canyon are relicts from a time when climactic conditions were different and springs were more widespread (Blinn, Stevens, and Shannon 1994

Aquatic Flora and Invertebrate Fauna

Mainstem. Since 1995 the aquatic community has been dominated by a mixed green algae (primarily *Ulothriz zonata*, *Spirogyra* spp.) and macrophyte assemblage (*Fontinalis* spp. and *Chara contraria*) (Benenati et al. 2000). Although the previous dominant for about 30 years, *Cladophora glomerata,* is still present, it is greatly diminished, probably as a result of changes in reservoir / river chemistry and discharge regimes that occurred in 1995 (Benenati et al. 2000). Prior to August 1995, *Cladophora* composed 90% of the algal community (Benenati et al. 2002). *Cladophora* is a keystone species and superior algal host over other green filamentous algae and macrophytes due to its ability to support greater numbers of larger and more easily grazed diatoms that feed invertebrates and fishes. Primary consumers include nonnative species such as scuds, midges, black flies, and snails, including the invasive New Zealand mudsnail.

Tributaries and Springs. Tributaries are an important source of aquatic invertebrates for the Colorado River; they contribute biomass to the mainstem drift and increase the diversity of the food base for fish (Shannon et al. 1996). Common species include caddis flies, mayflies, midges, blackflies, and stoneflies. The New Zealand mudsnail has recently been found in at least five of the 23 tributaries sampled. River runners may inadvertently be spreading these pests (Shannon et al. 2003). For example, the mudsnail was not collected above the confluence of Havasu Creek in October 2003, but was collected in low numbers (less than 20 per square meter) in October 2004 at the first crossing above a series of waterfalls where river runners wade.

Tributaries are vital for the persistence of native fish populations and provide critical year-round spawning grounds for adult fish and rearing areas for juveniles. Western native fish have evolved the ability to spawn multiple times, from spring to fall, usually triggered by flash floods, photo-period, and water temperature. In 2000 researchers reported that native suckers can be in spawning condition into October within Grand Canyon tributaries (Douglas and Douglas 2000), and other researchers documented that the native Little Colorado spinedace can reproduce three times between May and July (Blinn et al. 1998). Fall into winter is suspected to be an important growth period for young of the year humpback chub, according to a review of 30 years of data by Meretsky et al. (2000).

In 2002 a researcher reported that many seeps and springs in the Grand Canyon supported unusual and rare insects, particularly on dripping backwall habitats (Spence 2002). Observations included new documentation for a species of *Ochterus* (Hemiptera), an undescribed species of *Clinocera* (Diptera), and a possible undescribed species in the neotropical genus *Asymphyloptera* (Diptera). The federally endangered Kanab ambersnail is native to vegetation surrounding the springs at Vasey's Paradise and at a translocation site in Royal Arch Creek-Elves Chasm.

Native Fishes

Half of the native fish species historically known from Grand Canyon have been locally extirpated. Their loss has been attributed to two primary factors: (1) habitat degradation caused by construction and operation of Glen Canyon Dam, and (2) predation and competition from nonnative fishes (Douglas and Douglas 2000). Adult native fish persist in the mainstem, but the recruitment of young fish has been significantly limited by cool river temperatures and inconsistent habitat availability, as well as nonnative fish predation (Douglas and Marsh 1996;

Gorman and Stone 1999). Many native fishes spawn in the warmer waters of tributaries, including the Paria River, the Little Colorado River, Shinumo Creek, Kanab Creek, and Havasu Creek (Robinson et al., 1996).

Only four native fish species are regularly found in the Colorado River in Grand Canyon — the humpback chub, flannelmouth sucker, bluehead sucker, and speckled dace. A fifth species, the razorback sucker, is extremely rare and has probably been extirpated from the canyon. The humpback chub and razorback sucker (federally endangered species) and the flannelmouth sucker (federal species of concern) are addressed in "Endangered, Threatened, and Sensitive Species." The bluehead sucker and speckled dace, which currently have no special management status, are addressed below.

Bluehead Sucker — Bluehead suckers are found throughout the Colorado River basin in mainstem habitats, but they are more common in tributaries and their inflows (Valdez et al. 1998). In clear water adults occupy deep pools and eddies during the day and move to shallow riffles, tributary mouths, or shorelines to feed at night (Converse, Hawkins, and Valdez 1998). In turbid conditions they remain in shallow habitats day and night. In 1999 researchers found bluehead suckers in 10 tributaries during spring and summer (Valdez and Hoffnagle 1999). Spawning occurs from mid-March through June in Shinumo Creek, Kanab Creek, the Little Colorado River, and probably in other tributaries. The distribution of bluehead suckers in the Grand Canyon appears to have remained the same since the 1970s, but relative abundance may be decreasing; no population estimates are available.

Speckled Dace — Speckled dace are one of the most widespread fish species in western North America; they are common in the Colorado River and its tributaries in the Grand Canyon (Valdez et al. 1998). They are found most often in shoreline habitats, along sandbars, at tributary mouths, and in the tributaries themselves (Minckley and Deacon 1991; Valdez and Hoffnagle 1999). Spawning occurs in spring and autumn and takes place in tributaries. The abundance of speckled dace in Bright Angel Creek declined from common in the 1970s (Minckley 1978) to very rare in the 1990s, at the same time as a decrease in the abundance of rainbow trout and an increase in brown trout (Otis 1994). In other tributaries where brown trout are less common, speckled dace occur in large numbers (Allan 1993; Weiss 1993).

Nonnative Fishes

Twenty-six species of nonnative fish have been collected in the Grand Canyon (Valdez et al. 1998). Nonnative fish were introduced to the Colorado River system as early as the 1800s and were altering the native fish population structure in the Grand Canyon well before the completion of Glen Canyon Dam (Carothers and Brown 1991; Leibfried 1999). The changes in mainstem habitat conditions subsequent to dam construction have benefited some nonnative fishes, especially rainbow trout and brown trout , which were previously restricted to cool, clear tributaries. At the same time, these changes apparently limited the success of some warm-water species, notably channel catfish and common carp, which were reported in greater abundance and wider distribution in the 1970s than in recent years (Carothers and Minckley 1981; Valdez and Ryel 1995). Competition and predation between introduced and native fishes have been

implicated in the decline and extinction of native fishes throughout the Colorado River basin (Meretsky et al. 2000; Douglas and Marsh 1996; Converse, Hawkins, and Valdez 1998).

Introduced trout now dominate the fish assemblage in the mainstem of the Colorado River. Current population estimates for rainbow and brown trout combined between RM 39 and RM 196 exceed 380,000 adults (Speas et al., 2003), more than 100 times the estimated humpback chub population. Rainbow trout account for about two-thirds of the total trout population. The number of rainbow trout in the mainstem decreases downstream from the Little Colorado River, coincident with increased turbidity and declining food resources; in this section of the river trout have a greater dependence on tributaries and tributary inflows. Rainbow trout spawn in several streams, including Nankoweap, Bright Angel, Tapeats, and Deer Creeks. Bright Angel Creek is the primary spawning tributary for brown trout (Leibfried et al. 2003). Efforts by the National Park Service and the Grand Canyon Monitoring and Research Center are currently underway to reduce trout population densities at selected Grand Canyon sites to relieve predation and competitive pressures on the endangered humpback chub and other native fishes.

TABLE 3-9: COMMON INTRODUCED FISH SPECIES IN THE COLORADO RIVER IN GRAND CANYON

Warm-Water Species	Cold-Water Species
Channel catfish (*Ictalurus punctatus*)	Brown trout (*Salmo trutta*)
Common carp (*Cyprinus carpio*)	Rainbow trout (*Oncorhynchus mykiss*)
Fathead minnow (*Pimephales promelas*)	
Plains killifish (*Fundulus zebrinus*)	
Red shiner (*Cyprinella lutrensis*)	
Striped bass (*Morone saxatilis*)	

DIAMOND CREEK TO LAKE MEAD

When Lake Mead is at full pool it extends past the Separation rapid at RM 242. In comparison to the eastern Grand Canyon, the mainstem below Diamond Creek is turbid more often, reducing benthic biomass by a factor of three and thereby supporting fewer fish. Nonnative fish, such as striped bass, which prey on native fishes, swim upriver from Lake Mead into the Lower Gorge and beyond. In 1999 researchers reported a precipitous decline in speckled dace below Bridge Canyon (RM 235), where nonnative red shiners became abundant (Valdez and Hoffnagle 1999). The last observations of razorback suckers, which are probably extirpated from Lees Ferry to Diamond Creek, were in the western Grand Canyon during high lake levels in the 1990s (see "Endangered, Threatened, and Sensitive Species").

The slower moving water and clay / silt sediments in the Lower Gorge favor the creation of marsh habitat that provides shelter and refuge for aquatic species. Insects are abundant in the marsh vegetation and provide a food source for lake fish and insectivorous birds.

Western Grand Canyon tributaries provide habitat for native and introduced fishes, but also house rare species such as the relict leopard frog (Drost, pers. comm. 2004). Some seeps and springs, including Travertine Falls, Diamond Creek, and Spencer Creek, have been designated by the Hualapai Tribe as water sources specifically for aquatic and terrestrial wildlife.

ENDANGERED, THREATENED, AND SENSITIVE SPECIES

One of Grand Canyon National Park's management objectives is to "manage ecosystems to preserve critical processes and linkages that ensure the preservation of rare, endemic, and specially protected (threatened / endangered) plant and animal species" (NPS 1995b). Included are species federally listed as endangered or threatened, proposed for listing, or candidates for listing as determined by the U. S. Fish and Wildlife Service; all such species receive the full protection of the Endangered Species Act of 1973, as amended. Table 3-10 includes all federally protected wildlife and plant species that have been recorded or are likely to occur within the area potentially affected by river recreationists in the park. The table also lists species that are not protected under the act but that have been granted special status by various agencies because of concern over low or declining populations, threats to the species within its range, or because the species is considered to have particular ecological importance. In addition to species listed by the Fish and Wildlife Service are plants and animals that have been recognized by the Arizona Game and Fish Department, the Arizona Department of Agriculture, and the Navajo Nation's Department of Fish and Wildlife. No plant in the park may be removed without a federal permit; plants listed by the Arizona Department of Agriculture also require a permit from that agency and payment of salvage fees. All special status species managed to assist in their preservation.

TABLE 3-10: ENDANGERED, THREATENED, AND OTHER SPECIAL STATUS SPECIES KNOWN TO OR LIKELY TO OCCUR IN THE COLORADO RIVER CORRIDOR IN GRAND CANYON NATIONAL PARK

Common Name	Scientific Name	Status*		
		Federal	State	Navajo**
Lees Ferry to Diamond Creek — Wildlife				
Invertebrates				
Grand Canyon cave pseudoscorpion	*Archeolarca cavicola*	SC	-	-
Kanab ambersnail	*Oxyloma haydeni kanabensis*	E	-	-
Fish				
Flannelmouth sucker	*Catostomus latipinnis*	SC	-	-
Humpback chub	*Gila cypha*	E	WSCA	G2
Amphibians				
Northern leopard frog	*Rana pipiens*	-	WSCA	G2
Birds				
American peregrine falcon	*Falco peregrinus anatum*	-	WSCA	-
Bald eagle	*Haliaeetus leucocephalus*	T	WSCA	-
California brown pelican	*Pelecanus occidentalis californicus*	E	-	-
California condor	*Gymnogyps californianus*	XN	WSCA	-
Mexican spotted owl	*Strix occidentalis lucida*	T	WSCA	G3
Southwestern willow flycatcher	*Empidonax traillii extimus*	E	WSCA	G2
Mammals				
Allen's Lappet-browed bat	*Idionycteris phyllotis*	SC	-	-
Greater western mastiff bat	*Eumops perotis californicus*	SC	-	-
Mexican Long-tongued bat	*Choeronycteris mexicana*	SC	C	
Pale Townsend's big-eared bat	*Corynorhinus townsendii*	SC	-	-
Pocket Free-tailed bat		SC	S2S3	
Spotted bat	*Euderma maculatum*	SC	C	-
Western red bat	*Lasiurus blossevillii*	-	C	-
Long-legged myotis	*Myotis volans*	SC	-	-
Southwest river otter	*Lontra canadensis sonora*	SC	WSCA	G1
Desert bighorn sheep	*Ovis canadensis mexicana*	-	-	G3
Lees Ferry to Diamond Creek — Plants				
Grand Canyon beavertail cactus	*Opuntia basilaris* var. *longiareolata*	3b	SR	-
Kaibab agave	*Agave utahensis* ssp. *kaibabensis*	3c	SR	-
McDougall's yellowtops	*Flaveria mcdougallii*	3c	SR	-

Common Name	Scientific Name	Status*		
		Federal	State	Navajo**
Diamond Creek to Lake Mead — Wildlife				
Fish				
Razorback sucker***	*Xyrauchen texanus*	E	WSCA	G2
Amphibians				
Relict leopard frog	*Rana onca*	C	WSCA	-
Reptiles				
Desert tortoise (Sonoran population)	*Gopherus agassizii*	SC	WSCA	-
Birds				
Yellow-billed cuckoo	*Coccyzus americanus*	C	WSCA	G3
Yuma clapper rail	*Rallus longirostris yumanensis*	E	-	-
Diamond Creek to Lake Mead — Plants				
Cave-dwelling primrose	*Primula specuicola*	3c	SR	-
Kaibab suncup	*Camissonia specuicola* ssp. *hesperia*	SC	-	-

SOURCE: to 66 FR 54808; 50 CFR 17.11–17.12; AGFD 2003; Brian 2000; GRCA 2003; species names conform to the Integrated Taxonomic Information System (ITIS).

* Federal Status:
E — Endangered, in danger of extinction.
T — Threatened, severely depleted.
C — Candidate for listing as threatened or endangered.
XN — Experimental, non-essential population; in Grand Canyon condors are managed as federally endangered.
SC — Species of Concern. Some information showing vulnerability or threat, but not enough to support listing.
3b — No longer considered for federal listing; does not meet the Endangered Species Act's definition of "species." Species in this category are included only because they are also "Salvage Restricted" in Arizona.
3c — No longer considered for federal listing; proven to be more widespread or abundant than previously thought. Species in this category are included because they are also "Salvage Restricted" in Arizona.

State Status:
WSCA–Wildlife of Special Concern in Arizona.
SR–Listed as salvage restricted by the Arizona Department of Agriculture; the plant is subject to damage by theft or vandalism; a state permit and salvage fees required for removal.

Navajo Endangered Species List:
Group 1 (G1) — No longer occurs on Navajo Nation lands.
Group 2 (G2) — Prospect of survival or recruitment is in jeopardy.
Group 3 (G3) — Prospect of survival or recruitment is likely to be in jeopardy in the foreseeable future.

** Navajo status determination is not used by any other affiliated Grand Canyon tribes.

*** No longer occurs in Grand Canyon; presumed extirpated.

LEES FERRY TO DIAMOND CREEK

Wildlife

Invertebrates

Grand Canyon Cave Pseudoscorpion. The Grand Canyon cave pseudoscorpion (a USFWS species of concern) is similar in appearance to a scorpion, but it does not have a telson or stinger. Their population status within Arizona is unknown, and little is known about their life history. Most pseudoscorpions live among debris and in decaying cacti (Biota Information System of New Mexico 2000); however, cave pseudoscorpions differ in that they live in rodent middens that are found inside caves (Spiller, pers. comm. 1991; AGFD 2003a). All species typically have highly localized distributions, low dispersal, and cannot live outside the cave (AGFD 2003a). One female specimen that was collected in a cave off the Grandview Trail was 3 mm long with a reddish-brown carapace (Leslie, pers. comm. 2003). Several other specimens were confirmed in two caves in the Lower Gorge (Hill and Polyak 2004).

Kanab Ambersnail. The federally endangered Kanab ambersnail is known from three extant populations: one in Kane County, Utah (a second population there appears to be extirpated); one at Vasey's Paradise along the Colorado River in Grand Canyon National Park; and an introduced population in upper Elves Chasm, also in the park (USFWS 1995; Sorenson, pers. comm. 2003). The Elves Chasm population was successfully established by the Arizona Game and Fish Department in 1998 (AGFD1998b; Sorenson, pers. comm. 2003). At Vasey's Paradise the ambersnail occupies a spring-fed wetland habitat of cardinal monkeyflower and watercress above the 20,000 cfs waterline stage (USFWS 1995). Vasey's Paradise is a popular attraction site for river recreationists, who often stop to draw water from the spring or fish the eddy.

PHOTO 3-2: KANAB AMBERSNAIL

Arizona Game and Fish Department photo

Fish

Flannelmouth Sucker. The flannelmouth sucker (a USFWS species of concern) is found in the mainstem of the Colorado River throughout Glen Canyon National Recreation Area and Grand Canyon National Park, and in most the tributaries, including the Paria River, the Little Colorado River, Bright Angel Creek, Kanab Creek, Shinumo Creek, and Havasu Creek (Valdez et al. 1998). Tributaries and confluence areas have generally had higher densities of this species than the mainstem and are the most likely sites for successful reproduction (Valdez and Ryel 1995). Spawning occurs March through July and has been reported from the Paria River, the Little Colorado River, and Shinumo, Bright Angel, Kanab, Havasu, Spencer, and Surprise Canyon creeks (Valdez et al. 1998; AGFD 2001a). Mainstem spawning has also been documented in the tailwaters of Glen Canyon Dam (apparently unsuccessful because of cold water temperatures) and in the western Grand Canyon (AGFD 1996; McKinney et al. 1999). Young fish are generally found in submerged vegetation where they feed and hide (Mueller and Marsh 2002). The canyonwide population of flannelmouth suckers has never been formally estimated but is considered to be relatively stable (Valdez et al. 1998).

Humpback Chub. Critical habitat for the federally endangered humpback chub has been designated in Grand Canyon National Park from about RM 35 to about RM 209 (59 FR 13374). The chub is also listed by the Arizona Game and Fish Department and the Navajo Nation. Humpback chub are found in canyon-bound reaches of large rivers (Colorado, Little Colorado, Green, and Yampa) with turbulent flow (AGFD 2001b). Larvae and juvenile fish prefer shallow, low-velocity, nearshore habitats. With increasing size and age, the fish move to deeper areas with faster current. Of the 10 aggregations that have been identified in the park, the two largest are those found in the Little Colorado River and in the mainstem near the confluence. Spawning for both of these aggregations occurs in the Little Colorado River, generally commencing in late March, peaking in mid-April, and waning in mid-May (Valdez et al. 1998). Humpback chub have been observed ascending the Little Colorado River from the mainstem as late as July (Valdez and Ryel 1995). The eight smaller mainstem

PHOTO 3-3: HUMPBACK CHUB

NPS photo

aggregations consist primarily of adults, although a few juvenile fish have been found far from the Little Colorado River, suggesting that limited spawning may take place in the mainstem.

Population estimates made in 2001 and 2002 for the humpback chub aggregations in and near the Little Colorado River indicate a real and significant decline in numbers over the last decade (Van Haverbeke and Coggins 2003; Van Haverbeke 2003). In an overview of status and trend of the humpback, biologists from the Grand Canyon Monitoring and Research Center estimate that the current spawning population is probably somewhere between 2,000 and 4,000 for age four and older fish, possibly a 50% decline since 1990 (GCMRC 2003a). They have attributed the decline to habitat modification and predation and competition by nonnative fish species. A program recommended by the Glen Canyon Dam Adaptive Management Work Group to reduce nonnative fish, particularly rainbow trout, to benefit the humpback chub was approved by the Secretary of the Interior in 2002 and begun in January 2003. It includes an attempt to disrupt trout breeding and habitat by varying daily flows from Glen Canyon Dam during the trout's spawning and rearing seasons (January through March) and by mechanically removing nonnative fish, primarily rainbow and brown trout, from about 16 miles of the Colorado River around the mouth of the Little Colorado River (GCMRC 2003b; Yard and Coggins 2003).

Amphibians

Northern Leopard Frog. The northern leopard frog (listed as an Arizona species of special concern and as a species in jeopardy by the Navajo Nation) occurs in northeastern and north-central Arizona in and near permanent water with rooted aquatic vegetation, generally at elevations from about 2,640 to 9,155 feet (AGFD 2002b). These frogs utilize springs, streams, and ponds, as well as moist habitat in grasslands, brush lands, woodlands, and forests. Breeding takes place March through May, eggs are deposited on submerged vegetation in shallow water, and tadpoles transform to frogs June through August (Miller et al. 1982). Leopard frogs (either adults or tadpoles) were historically observed at one locality along the river in the Grand Canyon and in several tributaries. One extant population is known to occur along the river in Glen Canyon a few miles upstream of the park boundary (Spence 1996). A survey to determine the status of northern leopard frog populations within the Colorado River corridor is being conducted by the National Park Service.

Birds

American Peregrine Falcon. The American peregrine falcon was listed as endangered in 1970; however, recovery efforts were successful, and the species was removed from the list in 1999. This species is now considered a species of concern by the U. S. Fish and Wildlife Service and is listed as an Arizona species of special concern. To ensure the peregrine falcon's recovery in Grand Canyon, the park will continue to treat the species as endangered until 2004. Currently, over 50 pairs nest in the park, and a monitoring program has been developed (Leslie, pers. comm. 2003; Ward 2000). Peregrines use areas with high massive cliffs, preferably near water, where bird concentrations are relatively high.

PHOTO 3-4: PEREGRINE FALCON

USFWS photo

PHOTO 3-5: BALD EAGLE

USFWS photo

Bald Eagle. The bald eagle, which was listed as endangered in 1967, was reclassified as threatened in the lower 48 states in 1995, and was proposed for delisting in 1999. The bald eagle is listed by the Arizona Game and Fish Department. Bald eagles are found in all counties of Arizona, typically near lakes and rivers where they forage for fish (AGFD 2002d). They arrive in Grand Canyon as early as the last week of October and typically leave by the third week of March (Jurgensen, pers. comm. 2004). Bald eagles roost and nest in large trees or on cliffs or pinnacles near the water, but nesting does not occur in the Grand Canyon (Brown and Stevens 1992). In the 1980s and early 1990s many bald eagles congregated at the mouth of Nankoweap Creek to feed off spawning rainbow trout. Their numbers have been greatly reduced in recent years since changes in stream morphology have hampered movement of trout into the creek and reduced foraging opportunities for eagles. Despite the diminished use of Nankoweap Creek, bald eagles remain the most frequently seen raptor along the river in winter (Yard, pers. comm. 2003b). Bald eagles have been observed along the river corridor from Lees Ferry to RM 105 (Leslie, pers. comm. 2003). Monitoring of wintering bald eagle populations has begun in Grand Canyon and will continue through 2005 (Ward 2004).

California Brown Pelican. The federally endangered brown pelican is a subspecies of the brown pelican that is found mostly along the California and Mexico coasts (USFWS 2001); however, it has been observed inland in Arizona along the Colorado River, near Lake Mead and in Gila Valley, and near other bodies of water throughout the state. Winter sightings of the California brown pelican are occasionally recorded from Grand Canyon National Park, but it is an infrequent winter migrant (Leslie, pers. comm. 2003).

PHOTO 3-6: CALIFORNIA CONDOR

USFWS photo

California Condor. The federally endangered California condor has critical habitat designated in California. An experimental, nonessential population was reintroduced into northern Arizona and southern Utah in December 1996, and the Arizona Game and Fish Department now lists this species. Experimental populations in national parks are managed as a threatened species. As of 2004, 44 free-flying condors, including six breeding pairs, inhabited the Grand Canyon area (Leslie, pers. comm. 2004b). The first wild reared chick in the program's history and likely the first chick in Arizona in 100 years fledged in November 2003. Since then, two additional chicks have been born. Condors are known to create nesting sites in various rock formations, such as caves, crevices, and potholes (USFWS 2002b). Their preferred roosting habitat consists of rock cliffs, snags, and live conifer stands, where they can rest, preen, and socialize. Condors are known to prefer the river corridor in the winter months. Adverse human/condor interactions have been documented.

Mexican Spotted Owl. The federally threatened Mexican spotted owl has critical habitat designated within Grand Canyon National Park that includes portions of the river corridor (unit CP-10) (USFWS n.d.). Also listed as a species of concern by Arizona and the Navajo Nation, Mexican spotted owls are typically associated with mature forest habitat, and their presence has been confirmed within arid canyonlands scattered across southern Utah and northern Arizona (Willey 1995). Surveys within Grand Canyon National Park have recorded spotted owls within the upper reaches of several large, steep-walled tributary side canyons (Willey 2000). Habitat at these sites ranges from desert scrub to mixed coniferous forest. Radio-tracking studies have begun to determine nesting, roosting, and foraging sites used by this species (Ward, pers. comm. 2004).

PHOTO 3-7: MEXICAN SPOTTED OWL

USFWS photo

Southwestern Willow Flycatcher. Critical habitat for the federally endangered southwestern willow flycatcher (also listed as an Arizona species of special concern and a species in jeopardy by the Navajo Nation) was designated in 1997. Legal challenges have put the issue of critical habitat in doubt in Grand Canyon, but a resolution of the situation is expected in August 2004 (Ward, pers. comm. 2004). The critical habitat unit in Arizona encompasses approximately 32 miles of the Colorado River corridor within the Grand Canyon National Park (USFWS 2002d). Critical habitat is extensive on both sides of the river, including the Area of Cooperation between the Hualapai Tribe and the National Park Service. Typical nesting habitat contains dense, riparian woodland vegetation averaging 13 to 23 feet tall with a dense canopy cover (USFWS 2002d). Nesting occurs during the spring and early summer months in the park. During the rest of the year, flycatchers can be found in the tropical areas of Central America. In Grand Canyon National Park this species has been found only above 2,800 feet elevation along the river corridor in dense riparian habitat dominated by tamarisk, but including some willows (Sogge n.d.). Thick tamarisk and willow vegetation in the new high-water zone provide increasingly rare nesting opportunities for this riparian obligate species as habitat in other areas of the West is destroyed or fragmented. Ornithological surveys in June 2003 recorded the presence of two pairs of flycatchers at different locations near the river in the upper canyon (Yard, pers. comm. 2003b). A nest and one fledgling were observed at one of the sites.

PHOTO 3-8: SOUTHWESTERN WILLOW FLYCATCHER

NPS Photo

Mammals

Allen's Lappet-browed Bat. Allen's Lappet-browed bat (a USFWS species of concern) is found in Mexico, Arizona, and New Mexico (AGFD 2001c). Within Arizona, the bat occupies mountainous regions at higher elevations. Typical habitat includes ponderosa pine, pinyon / juniper, and riparian areas with sycamore, cottonwood, and willow. Individuals have also been observed in Mohave desert scrub and white fir. Boulder piles, cliffs, rocky outcrops, and lava flows also tend to be associated with their preferred habitat. Day roosts include rock shelters, caves, mines, and trees. The status of the Lappet-browed bat population along the Colorado River corridor is unknown, but individuals have been observed and collected in the river corridor (Leslie, pers. comm. 2003).

Greater Western Mastiff Bat. The greater western mastiff bat (a USFWS species of concern and an Arizona species of special concern) has been observed year-round in most Arizona counties, including Coconino and Mohave (AGFD 2002b) and has been recorded in Grand Canyon National Park. These bats prefer narrow, rocky canyon walls with many crevices in lower and upper Sonoran desert scrub habitat. They crowd into tight, deep crevices and are able to crawl through small passageways to reach the roosting site.

PHOTO 3-9: TOWNSEND'S BIG-EARED BAT

NPS Photo

Pale Townsend's Big-eared Bat. The Pale Townsend's big-eared bat (a USFWS species of concern) is found in Arizona from the vicinity of the Grand Canyon to the southeastern portion of state (AGFD 1998a). Habitat types used by this bat include desert scrub, oak woodland, oak / pine forests, pinyon / juniper forests, and coniferous forests. Caves are a preferred location for day roosts in summer and hibernation in winter. Stanton's Cave, once the site of the largest maternity colony of this species west of the Rocky Mountains, was abandoned by 1986 as a result of visitation by river runners, scientific excavations, and fencing across the entrance (Quinn and Petterson 1997; Leslie, pers. comm. 2003). This species is sensitive to disturbance and often abandons maternity colonies as a result of human activity. A gate designed to keep out human visitors but allow entry by bats was installed in 1997, and the cave is once again home to a maternity colony of this species.

Spotted Bat. The spotted bat (a USFWS species of concern and an Arizona species of special concern) is found in central western North America, from Canada to Mexico (AGFD 2002e). Multiple populations have been found throughout Arizona, with a fairly large one near the Utah-Arizona border. In Arizona this species has mostly been collected from dry, rough desert scrub, although a few have been documented in ponderosa pine forest. They roost in small cracks in rocky cliffs. Spotted bats have been collected from the canyon rim to the river throughout the park (Leslie, pers. comm. 2003).

Western Red Bat. The western red bat (classified as an Arizona species of special concern) ranges from southern Canada to South America, where it migrates during the winter (AGFD 2002e). It resides in Arizona from April through September and is found primarily in riparian and woodland habitats. Roosting sites are located in the foliage of trees and shrubs. Fewer than 100 individuals have been sighted throughout the state. It is dispersed throughout the Grand Canyon river corridor and has been observed and collected at various locations from Bright Angel Creek to Diamond Creek (Leslie, pers. comm. 2003).

Long-legged Myotis. The long-legged myotis bat (a USFWS species of concern) ranges from southeastern Alaska and western Canada to central Mexico (AGFD 1997b). Its preferred habitat type is coniferous forests, but riparian and desert habitats are occasionally used. Typical roosting sites include abandoned buildings, cracks in the ground, cliff crevices, and behind exfoliating tree bark. Caves are used for hibernating in winter. Long-legged myotis have been collected along the river corridor and use it for foraging and other habitat requirements (Leslie, pers. comm. 2003).

Desert Bighorn Sheep. Preferred habitat for the desert bighorn sheep (classified by the Navajo as potentially in jeopardy in the future) is rough, rocky, sparsely vegetated land, characterized by steep slopes, canyons, and washes. They tend to stay within a few miles of perennial water, but they also utilize ephemeral pools and moisture from succulent plants (Hoffmeister 1986). Breeding occurs July through September, peaking in August. Lambing typically occurs in February; once lambing commences, bighorn move to lower elevations. Bighorn are commonly seen on rocky cliffs along the Colorado River. In a 2002 NPS-sponsored survey, approximately 100 to 120 sheep were counted from the river (NPS 2003k). Little is known about the population status of desert bighorn sheep in the park.

Southwest River Otter. The southwest river otter (a USFWS species of concern and an Arizona species of special concern, but considered extirpated from Navajo lands**)** is the only subspecies of *L. canadensis* native to Arizona, although a different subspecies, *L. canadensis lataxina*, was introduced into the Verde River in central Arizona between 1981 and 1983 (AGFD 2002f). The southwest river otter is a rare inhabitant of the aquatic communities of Arizona (Hoffmeister 1986); however, rivers, streams, lakes, and marshes with adequate prey all provide potential habitat (AGFD 2002f). Sightings prior to the construction of Glen Canyon Dam indicate that river otters were present within the Colorado River corridor at one time, but at low densities. Since the late 1950s, scat and a few tracks seen along the river may possibly have been those of a river otter (Compton 2000). During a May 2000 wildlife inventory trip, a series of tracks in Grand Canyon were photographed, which were confirmed by experts to be otter tracks. Later in the summer of that same year, a pair of otters was observed by NPS wildlife staff on Lake Powell. The otter tracks in Grand Canyon are believed to have been those of a lone, juvenile male possibly originating from the Glen Canyon pair (Leslie 2000b). It is unlikely that these otters were the native Sonoran species and most probably were dispersed animals from nonnative species that were introduced into the Colorado River drainage by the Arizona Game and Fish Department between 1978 and 1991 (GRCA wildlife files 1999). The status of this species in Grand Canyon National Park is uncertain; however, a viable population does not exist (Leslie, pers. comm. 2003).

Plants

Grand Canyon Beavertail Cactus. Grand Canyon beavertail (classified as salvage restricted by the Arizona Department of Agriculture but no longer considered for listing by the U. S. Fish and Wildlife Service) is a member of the cactus family. This succulent perennial has spineless spatulate joints and light cerise to vivid purplish red flowers. Grand Canyon beavertail grows on gravelly or rocky slopes in the Granite Gorge, at an elevation of 2,350 to 4,000 feet (Brian 2000). Hikers from river trips may trample or dislodge this plant; however, people tend to avoid cacti, assuming that they have spines.

Kaibab Agave. Kaibab agave (classified as salvage restricted by the Arizona Department of Agriculture but no longer considered for listing by the U. S. Fish and Wildlife Service) is a member of the agave family, has large, robust, straight leaves, and yellow rosettes growing along the upper portion of a slender stalk that can reach 12 feet or more in height. This plant grows on moderately to sloping ledges of limestone- and sandstone-derived soil in desert scrub, at an elevation of 1,200 to 7,200 feet (Brian 2000).

McDougall's Yellowtops. McDougall's yellowtops (classified as salvage restricted by the Arizona Department of Agriculture but is no longer considered for listing by the U. S. Fish and Wildlife Service) is also known as McDougall's flaveria. With stems up to 3 feet tall, this member of the sunflower family has narrow, linear leaves and a flat-topped blossom composed of numerous tiny, yellow florets (Arizona Rare Plant Committee 2001). This plant grows in moist saline seeps with maidenhair fern and monkey-flower, and on open slopes in Muav limestone and Bright Angel shale at an elevation of 1,800 to 1,670 feet (Brian 2000).

DIAMOND CREEK TO LAKE MEAD

Many of the threatened, endangered, and sensitive species found in the upper stretch also inhabit the Lower Gorge. Sensitive or listed species that are not known to occur in Grand Canyon above Diamond Creek include the razorback sucker, relict leopard frog, desert tortoise, yellow-billed cuckoo, Yuma clapper rail, and Kaibab suncup.

Spencer Canyon has been included as a site to be managed through the Lower Colorado River Multi-Species Conservation Program. Management actions in these side canyons would result in the preservation, creation, and/or restoration of habitat for the southwestern willow flycatcher and yellow-billed cuckoo. Habitat may also be created to support the Yuma clapper rail and other marsh and aquatic wildlife.

Wildlife

Fish

Razorback Sucker. The razorback sucker (federally endangered, an Arizona species of special concern, and a Navajo species in jeopardy) has designated critical habitat in the Grand Canyon that extends from about RM 0 (near the Paria River) to Hoover Dam. Razorback suckers prefer slower current and are found in backwaters, side channels, flooded bottomlands, pools, and lakes in the Colorado River drainage (AGFD 2002h). They spawn over clean gravel and cobbles in pond and river habitats from January into April (Mueller and Marsh 2002). In the lower Colorado River basin, razorback suckers are now restricted to Lakes Mohave and Mead, and possibly to the Colorado River in the Lower Gorge of Grand Canyon. This species is considered extremely rare in the park and may be extirpated here (Minckley 1991). Only 10 specimens, all adults, were collected between 1944 and 1990 (Valdez et al. 1998); no wild razorback suckers have been collected since 1990. In 1997 the Hualapai Tribe released 15 hatchery-raised razorback suckers into the Colorado River at three locations in the Lower Gorge (Zimmerman and Leibfried 1997). The results of this introduction are unknown.

Amphibians

Relict Leopard Frog. The relict leopard frog (a USFWS candidate for listing and an Arizona species of special concern) was considered extinct until small populations were located in the 1990s. This species persists in Nevada near the Overton Arm of Lake Mead and in Black Canyon below Hoover Dam (USFWS 2002c). Potential habitat in the form of small streams, springs, and

spring-fed wetlands between 1,214 and 2,494 feet above sea level exists within the area of analysis for this environmental impact statement. In 1997 a researcher found a decomposed leopard frog specimen in a Lower Gorge tributary, which was identified as a relict leopard frog (Stevens, pers. comm. 2004**)**. The National Park Service is currently conducting surveys to determine the status of the relict leopard frog in Grand Canyon. An extant population was recently confirmed in a small pool of water up a side canyon in the Lower Gorge (Drost, pers. comm. 2004), and one specimen has been documented on the Hualapai Reservation.

Reptiles

Desert Tortoise. The Sonoran population of the desert tortoise (a USFWS species of concern and an Arizona species of special concern) is found along the western end of the Grand Canyon and around Lake Mead (Leslie, pers. comm. 2003). Genetically distinct populations of the tortoise are divided by the Colorado River, with the Mojave population (federally threatened and an Arizona species of special concern) being located north and west of the Colorado River, and the Sonoran population occurring south and east of the Colorado River (Murray and Dickinson 1996). Critical habitat for the Mojave tortoise was designated in 1994 and includes areas adjacent to the Park in Lake Mead National Recreation Area. In the Lower Gorge in May 2004 biologists from Lake Mead and Grand Canyon discovered desert tortoise scat that has been confirmed as belonging to a Mojave desert tortoise (Leslie, pers. comm. 2004b). Further studies and inventories for Mojave desert tortoise will be initiated as a result of this discovery. The tortoise generally occupies creosote bush flats in basins and mountain bajadas, and it is occasionally found on rocky slopes. The Joshua tree forest along the rim in the Lower Gorge is an important component of desert tortoise habitat.

Birds

Yellow-billed Cuckoo. The yellow-billed cuckoo (a federal candidate species in the western U.S., an Arizona species of special concern, and a future jeopardy species for the Navajo Nation) prefers breeding habitat that includes large blocks of riparian woodland, consisting of cottonwoods, willows, and tamarisk. Nests are built in trees with dense understory foliage. Cuckoos arrive at their breeding grounds beginning in mid to late May and stay into September (Hughes 1999; AGFD 2000). Habitat for the yellow-billed cuckoo in the Grand Canyon only occurs below Diamond Creek in the western end of the river corridor (Leslie, pers. comm. 2003). In 2001 one individual was observed in the vicinity of Burnt Springs by San Bernardino College (San Bernardino College, pers. comm. 2001).

Yuma Clapper Rail. The current range of the Yuma clapper rail (federally endangered and an Arizona species of special concern) includes the Colorado River from the lower Virgin River to Mexico and various locations in the Gila River drainage (USFWS 2002f, 2003). Its preferred habitat is freshwater or brackish stream sides and marshlands at elevations under 4,500 feet. Nests are built 3–6 inches above the surface in sloughs and backwaters that support dense stands of bulrush and cattails, and breeding occurs from March to July. This species has been recorded within the lower end of the Colorado River corridor (Leslie, pers. comm. 2003). In 1996 and 1997 researchers reported the rail as occurring between Separation Canyon and the Lake Mead

delta (McKernan and Braden 2002). Three individuals were observed by the San Bernardino College in the vicinity of Burnt Springs in 2001 (San Bernardino College, pers. comm. 2001).

Plants

Cave-dwelling Primrose. The cave-dwelling primrose (classified as salvage restricted by the Arizona Department of Agriculture and no longer considered for federal listing) is a perennial plant in the primrose family, with long, spatula-shaped leaves and purple flowers clustered in umbels on a stalk that extends up to 11 inches above the basal leaves. This plant grows on limestone walls in seeps and in hanging gardens, at an elevation of 1,250 to 7,600 feet (Brian 2000). It has only been identified at the western end of the Grand Canyon, between Separation and Spencer Canyons.

Kaibab Suncup. The Kaibab suncup (a USFWS species of concern) is a densely tufted perennial that is a member of the evening primrose family. It has small flowers with four yellow petals (Arizona Rare Plant Committee 2001). The Kaibab suncup grows on sandy or gravelly beaches and in dry washes, often on limestone substrates, at an elevation of 2,300 to 3,500 feet (Brian 2000). It has been documented from a few side canyons along the Colorado River in the western end of the Grand Canyon (Brian 2000).

CULTURAL RESOURCES

LEES FERRY TO DIAMOND CREEK

CULTURAL OVERVIEW

The Grand Canyon of the Colorado is significant for its human history and its ongoing role in the lives and traditions of American Indians of the Colorado Plateau. Archeologists generally divide the nearly 12,000 years of human history in the American Southwest into four broad periods — Paleoindian, Archaic, formative, and historic — all of which are represented in Grand Canyon (Coder 2000). Paleoindian presence is indicated by a single Folsom preform projectile point dating to approximately 10,500 before present (B.P.). Evidence of Archaic occupation is more abundant but still sparse, consisting primarily of rock art panels, temporary campsites, and split-twig figurines dating to 3,000-4,000 B.P. The majority of prehistoric sites in Grand Canyon's eastern section date from the formative period (beginning around A.D. 500) and typically include Puebloan characteristics. This phase of prehistoric occupation ended mostly by 1150, but some areas were inhabited until at least the early 1200s. Limited occupation may have continued after that, but this has not been confirmed by physical evidence. Some prehistoric inhabitants of Grand Canyon moved to locations east of the canyon and are ancestral to modern Puebloan people (Ahlstrom et al. 1993). Artifactual evidence of the Pai (ancestors of the Hualapai and Havasupai Tribes), Paiute, and Cerbat occupation of Grand Canyon, particularly its western section, dates back to at least A.D. 1300 (Euler 1978). Pai occupation of areas along the Colorado River downstream of the Grand Canyon likely goes back many more centuries to at least A.D. 700 (Gilpin and Phillips 1998). For a summary of the Grand Canyon's prehistory see Coder (2000).

As documented by written records, the historic period (starting with European contact in 1540) witnessed the Navajo arrival and ongoing American Indian use, which included shelter, farming, hunting, gathering of plant and mineral resources, ritual, and refuge. Euro-American uses included exploration, mining, power production, and tourism. All prehistoric and historic uses are represented by archaeological sites along both the mainstem and side canyons of the Colorado River. Several American Indian groups in the region have expressed or claimed cultural affiliation to the Grand Canyon — the Havasupai Tribe, Hopi Tribe, Hualapai Tribe, Navajo Nation, Kaibab Band of Paiute Indians, Paiute Indian Tribe of Utah (representing the Shivwits Paiute), San Juan Southern Paiute Tribe, White Mountain Apache Tribe, and the Pueblo of Zuni (Neal and Gilpin 2000). The White Mountain Apache Tribe has recently indicated a historic connection to the Grand Canyon and the specifics are not yet known.

Researchers primarily think about the significance of cultural resources in terms of their potential to reveal new knowledge about human history and culture. Other groups have different points of view. Tourists on river-rafting expeditions often value the experience of seeing unexcavated archaeological sites and observing intact features and artifacts still scattered across the surface. American Indians see such sites as markers left by their ancestors, providing evidence of their ancestors' passage and continuing presence, and as places where traditional materials can be accessed. The historical nature of the river-running experience itself is also represented at sites in the Grand Canyon and is valued by those who make their living running the river and who

cherish the memories of those who have come before them. Therefore, the resources documented as archeological sites or traditional cultural places are likely to grow in number or to be redefined over time. Generally, despite the variation in points of view, the river's cultural sites have much value to many, including those who visit them and those who do not.

ARCHEOLOGICAL RESOURCES

Based on site records of Grand Canyon National Park and the Hualapai Tribe's Department of Cultural Resources (HDCR), a total of 674 archeological sites, both prehistoric and historic, are known to be along the Colorado River from Glen Canyon Dam to Lake Mead, and in side canyons below Lees Ferry within approximately a 2-mile hiking distance from the river (Fairley et al. 1994; Jackson 1997; GRCA files). Side canyon sites farther than 2 miles are included if they are known to be visited by river runners, based on conversations with Grand Canyon river guides, various publications, and park staff. Of the 674 sites, 487 are along the mainstem of the Colorado River and 187 are in side canyons. The number of mainstem sites is well documented as a result of an archeological inventory conducted in 1990–91 by NPS archeologists in conjunction with personnel from Northern Arizona University (Fairley et al. 1994). Little systematic survey of side canyons has been conducted, so the actual number of accessible sites in those locations is unknown. In 1992, 336 of the 487 mainstem sites were submitted to the Arizona State Historic Preservation Office for a formal determination of eligibility for listing on the National Register of Historic Places; 323 of these were determined eligible (NPS 1992). Many of the remaining mainstem properties have been assessed with regards to their national register eligibility, but no additional formal determinations have been conducted. Because the properties retain aspects of integrity in accordance with national register criteria, they are considered eligible for the register and are treated as such. The 187 known side canyon sites are considered eligible for the register as contributors to the Grand Canyon multiple property submission to the State Historic Preservation Office in 1980. In the subsequent evaluation (dated 1984), all properties covered by the submission were determined eligible for listing on the National Register of Historic Places (Balsom, pers. comm. 2003). Following current management practices, all of the documented archeological sites and traditional cultural properties (TCPs) within the Colorado River corridor and its side canyons are considered eligible for listing on the national register as contributors to the overall Grand Canyon multiple property nomination.

Evidence of prehistoric occupation in the Colorado River corridor is seen in the wide variety of recorded resource types, including pueblos, small habitation structures, storage features, rockshelters, thermal features and roasters, artifact scatters and caches, water control features, trails, rock art, a variety of isolated finds, and burials. Some archeological resources in the river corridor have been known since the 19th century, but many more sites were documented in limited surveys in 1965 and 1966, systematic site monitoring begun in 1978, and the river corridor inventory conducted in 1990–91 (Ahlstrom et al. 1993).

HISTORIC RESOURCES

Types of historic resources along the mainstem of the Colorado River and accessible side canyons include artifact caches and isolated occurrences, abandoned boats, dwellings, remnants of mining operations, camps, features related to dam site development, trails, inscriptions, and plaques. Of the total number of identified archeological sites along the mainstem, at least 71 have a Euro-American historical component (BOR 1995).

Historic resources represent Euro-American incursions into the Grand Canyon and the Colorado River beginning with the 1869 Powell expedition. Although physical remains from this journey do not exist, evidence from subsequent river explorations, beginning with the Stanton expedition in 1889, dot the confines of the river and its side canyons. Powell was not the first to explore the inner canyon, but he was the first to fully document the river itself. Over 200 years before Powell's journey, the earliest Spanish explorers gazed upon the river somewhere near Desert View, attempting to reach the Colorado River but never making it beyond a third of the way to the river (Winship 1964).

Evidence of historic uses of the Colorado River and side canyons dating between 1540 and the mid-1900s are numerous, with each location telling a story of past human endeavors. Mining and exploration are the principal activities documented in the historic record. Included in these sites are the remains of mining camps, Bureau of Reclamation dam survey sites, evidence of scientific explorations, and early river runners' camps (Fairley et al 1994).

TRADITIONAL CULTURAL PROPERTIES AND ETHNOGRAPHIC RESOURCES

American Indian groups in the region recognize certain tangible properties as important in their traditional tribal histories. These properties, which may or may not correspond to archeological sites, are referred to as traditional cultural properties (NPS, Parker and King 1990). Like historic properties, traditional cultural properties are given consideration under the National Historic Preservation Act of 1966, as amended. During research related to Glen Canyon Dam operations and sponsored by the Bureau of Reclamation, five tribes identified cultural resources of importance to them in the river corridor. A total of 324 known archeological sites were identified as traditional cultural properties by one or more tribal groups (NPS 2003j; Glassco 2003a). Of these 324 sites/ traditional cultural properties, the Hopi identify with 256 of them, the Hualapai Tribe with 118, the Pueblo of Zuni with 99, the Navajo Nation with 31, and the Southern Paiute Consortium with 2.

In addition to specific locations, American Indian people in the area hold many broader attributes of the Grand Canyon to be of traditional, even sacred, importance. Elders express a traditional veneration for the canyon's water, minerals, plants, and animals, and their oral traditions reveal a strong spiritual relationship to the Grand Canyon as a whole. The Havasupai and Hualapai Tribes revere the Colorado River as the backbone, or spine, of their lifeline. The Hopi Tribe and the Pueblo of Zuni consider the Grand Canyon to be the place of their emergence into the present world. To the Navajo people, the Colorado and Little Colorado Rivers are sacred female and male entities, respectively, and these rivers, as well as the canyons that engulf them, provide protection to the Navajo people. To Paiute peoples, the Colorado River is one of the most

powerful of all natural resources in their traditional lands, and the Grand Canyon has taken on special cultural significance as a place of refuge that has allowed their people to endure in the face of Euro-American encroachment (BOR 1995).

CULTURAL LANDSCAPES

As defined in the *NPS Cultural Resource Management Guidelines* (NPS 1998d), cultural landscapes are settings that humans have created in the natural world. They are intertwined patterns of things both natural and constructed, expressions of human manipulation and adaptation of the land. One type of cultural landscape, the historic vernacular landscape, is represented in the Colorado River corridor at both Lees Ferry and Phantom Ranch.

- At Lees Ferry, the Colorado River briefly flows free of canyon walls, historically the only place in over 400 miles that it could be accessed on both banks by wagon. This natural attribute has influenced the site's history for 130 years. Today, historic buildings and a cemetery, shade trees, an orchard, fields, trails, and dugways carved into the river bluffs combine with more contemporary structures to illustrate the site's use as a farm, a vital ferry link between settlements in Utah and Arizona, and an access point for river runners.

- At Phantom Ranch, major side canyons and perennial tributaries provided the natural context for what would become the nexus of a cross-canyon corridor and the most popular site in the inner canyon. Here, historic guest lodges and NPS buildings, livestock structures, cottonwood trees, a campground, bridges across Bright Angel Creek and the Colorado River, and a network of trails document 80 years of recreational activity at the very bottom of the Grand Canyon.

On a broader scale, the whole river corridor can be viewed as a cultural landscape in which American Indians for millennia have farmed, hunted, gathered plants and minerals, and performed rituals. Ancient trails, remnants of stone structures, traces of fields, and prayer objects enshrined in travertine and salt are enduring evidence of a subtly altered landscape. Integral to this landscape are the animals, plants, and minerals traditionally used and valued by American Indians. Today, tribes with traditional links to the Grand Canyon are concerned about the impact on these resources by Glen Canyon Dam operations and recreational river use. As part of an effort to protect culturally sensitive plants, several groups, including the Hopi, Hualapai, Navajo, Zuni, and Southern Paiute Consortium, have conducted ethnobotanical studies along the river in Grand Canyon to determine where such plants are located. A list of the plants identified by all these groups except the Pueblo of Zuni is on file at the park; the Pueblo of Zuni list is considered confidential.

DIAMOND CREEK TO LAKE MEAD

For cultural resources, the types and conditions discussed are similar to those described for the river corridor from Lees Ferry to Diamond Creek; however, differences do exist in the types and distribution of resources along the mainstem and the side canyons. The Hualapai Tribe, acting as their own Tribal Historic Preservation Office, inventories and monitors historic properties within the Hualapai Reservation. This work is done by the Hualapai Department of Cultural Resources.

Some of the cultural resources in this portion of the Colorado River are located within the Area of Cooperation, and the Hualapai Tribe and the National Park Service work cooperatively on the management of these resources.

ARCHEOLOGICAL RESOURCES

Archeological resources are less abundant in the Lower Gorge, in part due to the limited geomorphic conditions that would allow for prehistoric and historic uses. An additional factor is the limited archeological inventory, although inventory of the mainstem was conducted as part of the Glen Canyon Dam Environmental Studies (Fairly et al. 1994) and some side canyon inventory was conducted in the late 1980s as part of a research project with Wilderness Studies. The lower granite gorge precludes the existence of large, side canyon delta development, and access and egress is from side canyons with narrow junctions at the river. Inventory surveys have documented 16 mainstem sites and 53 side canyon sites. Sites in this area of the canyon are a mix of habitation and special use locations, characterized by rock shelters, artifact scatters, and roasting pit complexes. Few architectural sites exist, and human occupation spans the Archaic to the historic periods.

HISTORIC RESOURCES

Historic resources in this portion of the canyon primarily relate to the Bridge Canyon dam explorations. Bridge Canyon City and associated facilities are probably the most well-known historic site in the area. During the late 1950s scores of men occupied the area as part of the construction camp established for building Bridge Canyon Dam. Although the dam was never built, the encampment remains. Trails leading to and from the camp also exist.

The Bat Towers, leading to the Bat Cave, are well known remnants of a 1950s mining operation tram that connected the South Rim with the cave site on the north side of the Colorado River. Bat guano removed from the cave was marketed and sold as household plant fertilizer by the U.S. Guano Corporation.

TRADITIONAL CULTURAL PROPERTIES AND ETHNOGRAPHIC RESOURCES

Traditional cultural properties and ethnographic resources exist in this portion of the canyon. The Hualapai Tribe has documented 22 properties within the Lower Gorge (Glassco 2003b; NPS 2003j). There are only six traditional cultural properties in this section that are regularly monitored for impacts by HDCR, but they are all located at heavily visited areas (i.e., Diamond Creek, Bridge Canyon, Spencer Canyon, Travertine Canyon, Travertine Falls, and Burnt Springs) (Jackson, Kennedy, and Phillips 2002; Glassco 2003b).

CULTURAL LANDSCAPES

For the most part, the camp site at Bridge Canyon could be considered a historic vernacular landscape, although it has not been formally evaluated. The entire river corridor is thought of as an ethnographic landscape, as described above.

VISITOR USE AND EXPERIENCE

RECREATION VALUES

The Colorado River in Grand Canyon offers unique multiday river trips that are eloquently described in diverse guidebooks, travelogues, and other publications. Based primarily on boater responses to a survey question about the qualities that make the Colorado River through the Grand Canyon unique, "motor, oar, and private boaters agreed that the Colorado River in the Grand Canyon is better than other rivers they have run in its scenic views, sense of challenge, quality of the whitewater, length of time one can travel through an undisturbed environment, geological formations, and ability to have a life-changing experience" (Hall and Shelby 2000). The following summarizes key recreational attributes of Grand Canyon river trips (Hall and Shelby 2000), although only those with an asterisk can be measured:

- *Geological Formations* — The geological wonders of the Grand Canyon are well-documented (Breed and Roat 1974; Collier 1980; Beus and Morales 2003) and are uniquely experienced on trips that travel through the succession of rock layers on the river that carved the canyon.
- *Scenic Views* — The Grand Canyon has attractive beaches, side canyons, and riparian areas, including seeps, springs, and other water-enhanced micro-environments, that provide unique landscapes and scenic diversity.
- *Length of Trip through an Undeveloped Environment** — Grand Canyon river trips, particularly two- to three-week-long oar trips, offer unique opportunities to spend extended time in a backcountry, wilderness-like setting. The canyon is 226 miles from Lees Ferry to Diamond Creek, and boaters interested in longer trips can travel over 280 miles to takeouts on Lake Mead.
- *Quality of the Whitewater* — The Grand Canyon is famous for "big water" rapids. There are over 60 major (Class III/IV) rapids on the Colorado River through the Grand Canyon, and many have large waves and powerful hydraulics that rival any of the commonly boated rapids in the country.
- *Ability to Explore* — Most Grand Canyon trips offer extensive opportunities for recreationists to spend time at attraction sites or side canyons to explore natural, archeological, or historic features. There are several guides for hiking, natural history, archeology, and historical features that enhance exploration in the canyon (Powell 1961; Belknap 1969; Hughes 1967; Crumbo 1981; Butterfield, et al. 1981; Miller and Young 1981; Whitney 1982; Brown, Carothers, and Johnson 1987; Stevens 2002).
- *Sense of Challenge* — Whitewater, hiking, and camping trips offer challenges and require outdoor skills from at least some members of every group. Interested visitors have extensive opportunities to develop new skills or hone existing ones, often through interaction with commercial guides or noncommercial trip leaders/boat operators.
- *Sense of Freedom* — Many authors have written about achieving this cognitive/emotional state in wilderness-like areas, such as the Grand Canyon (Muir 1918; Abbey 1968, 1982).

- *Level of Naturalness** — Aside from launch and takeout facilities, a few corridor trails, and the rustic facilities at Phantom Ranch, the Grand Canyon as seen by river runners has little evidence of human development. Although there are human-caused impacts associated with Glen Canyon Dam, upstream water development, and invasive exotic vegetation, the canyon's environment appears largely shaped by the forces of nature, not humans.
- *Peace and Quiet** — With low levels of development, the Grand Canyon offers outstanding opportunities to experience "peace and quiet" and natural sounds, especially for non-motorized rafts during the no-motor season. Exceptions include nonnatural sounds from motorized craft, fixed-wing overflights, and helicopters.
- *Opportunities to Experience Solitude** — Opportunities for solitude (minimal contact with people outside one's own group) are plentiful on most Grand Canyon river trips, although complete solitude is rare except on winter trips. Due to user-day limits since 1972, most trips camp out of sight and sound of other groups on 80% of their nights in the canyon, average fewer than five on-river contacts per day, and encounter other groups at about half of the attraction sites they visit (Hall and Shelby, 2000). Solitude and an undeveloped environment are two fundamental issues defining a wilderness river experience (as defined in Chapter 1) associated with Grand Canyon river trips.
- *Ability to Have a Life-Changing Experience* — Attributes such as long trips, unscheduled days, opportunities for solitude, and the expansive setting of the Grand Canyon may facilitate self-transforming, experiences that contribute to life changing-experiences.
- *Opportunities to See Wildlife* — Mule deer and desert bighorn sheep are common mammals seen on river trips, as well as several common rodent and bat species. Coyote, ring-tailed cats, and mountain lions are more rarely encountered. There are also several amphibian and many lizard and snake species in the canyon. Seasonal birding opportunities can be exceptional on a river trip. Over 200 bird species have been identified by river users, although most birds are non-breeding migrants or transients. Prominent species include several teal, mergansers, and other ducks; hawks and other raptors, including peregrine falcons and bald eagles; and a diversity of songbirds, including swifts, hummingbirds, kingfishers, swallows, canyon wrens, warblers, tanagers, and sparrows.

Recreation researchers and managers recognize a spectrum of recreational opportunities available in outdoor settings, ranging from "pristine" to "paved" (Buist and Hoots 1982; Driver et al. 1987). This concept has been institutionalized in several federal and state land managing agencies, and it is a fundamental concept in most recreation planning frameworks (Shelby and Heberlien 1986; Stankey et al. 1985; Graefe, Kuss, and Vaske 1990; Crystal and Harris 1997; Manning 1999). It suggests that settings vary on a continuum for biophysical variables (pristine/natural to more developed/unnatural), social variables (low densities/interaction to high densities/interaction), and managerial variables (few regulations/minimal onsite presence to many regulations and greater onsite presence).

LEES FERRY TO DIAMOND CREEK (ZONE 1)

RECREATIONAL OPPORTUNITIES

River-running opportunities from Lees Ferry to Diamond Creek on the Colorado River are in Zone 1, which is on the "primitive" end of the recreational opportunity spectrum (ROS). Zone 1 has relatively low use densities, opportunities for solitude both on the river and at many camps and attraction sites, and low levels of development. The Lower Gorge section below Diamond Creek is in Zones 2 and 3 and is described later in this chapter.

Some elements of Grand Canyon river trips may seem to contradict a "primitive" label, including motorized boating use during most of the year, the use of helicopters at Whitmore; the use of helicopters or motorized boats for rescues and research, large group sizes (up to 44 people) on some commercial trips, and crowding or congestion at launches, takeouts, and some attractions. Use on the river is relatively highly managed. There are off-site permits and user-day limits primarily designed to reduce social impacts, as well as regulations and educational efforts designed to mitigate biophysical and other resource-based impacts. The following information describes the recreational opportunities available in Zone 1.

Trip Types and Group Size

Visitors may go with one of the 16 commercially guided trips (outfitters) or plan one of their own trips (noncommercial). Based on current user-day allocations and 1999–2002 data, 84% of visitors take commercial river trips and 16% noncommercial trips.

Commercial River Trips

Under current crew-to-passenger ratio regulations, commercial motorized trip sizes can conceivably be as high as 44. Of those taking commercial trips, 77% take motorized trips rather than non-motorized trips. Figure 3-3 illustrates the distribution of group sizes on one- and two-boat commercial motor trips (including guides). On one-boat commercial motor trips, group sizes average about 15 passengers plus crew (a total of 18); on two-boat trips, they average 28 plus crew (a total of 34). Approximately 10% of all motorized trips reach the limit of 36 plus crew (a total of 42+).

Figure 3-4 illustrates the distribution of group sizes for non-motorized commercial trips (including guides). Non-motorized commercial trips are generally smaller, averaging 18 passengers plus crew (a total of 24). These trips usually travel in four to six rafts. Non-motorized commercial trips seldom exceed 25 passengers plus crew (a total of 32).

FIGURE 3-3: COMMERCIAL MOTOR TRIP GROUP SIZE DISTRIBUTION CHART
(1999-2002 Data)

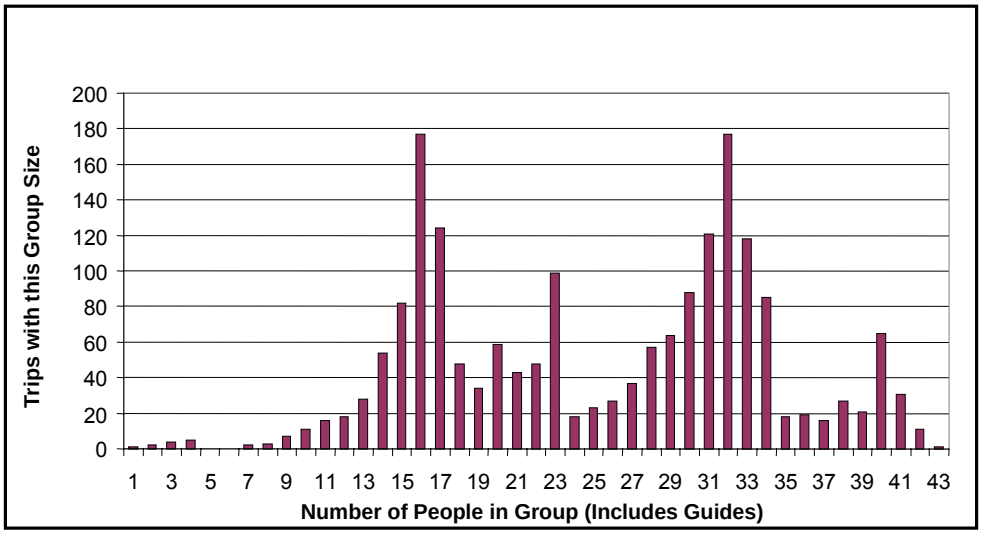
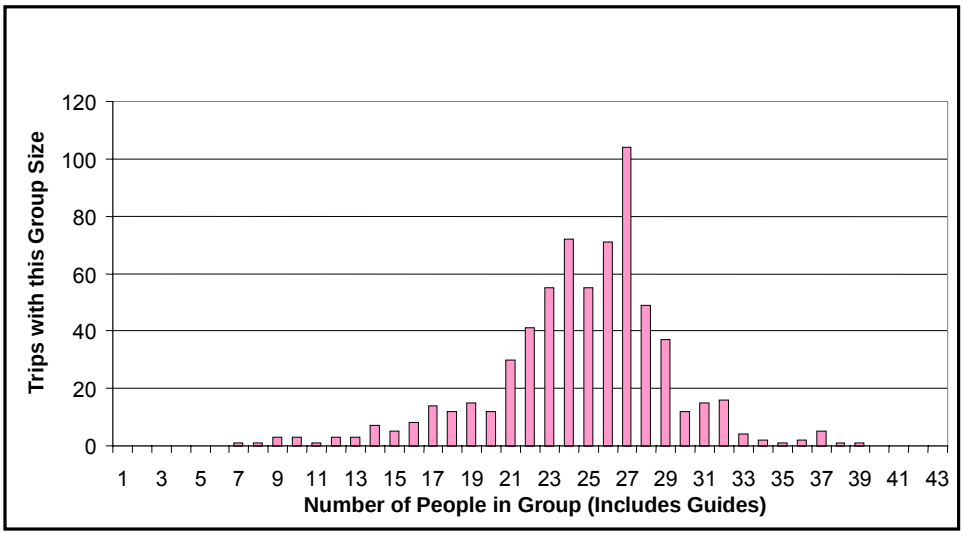


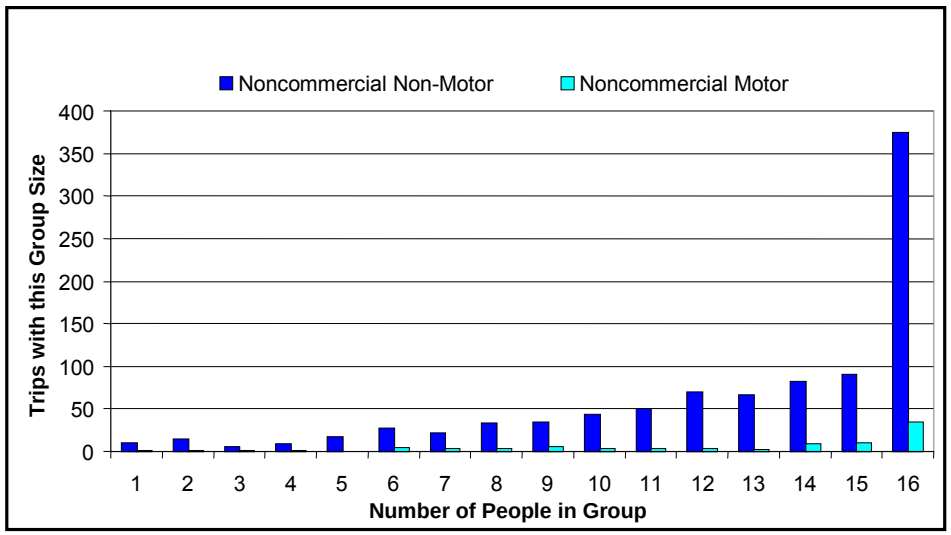
FIGURE 3-4: COMMERCIAL NON-MOTOR GROUP SIZE DISTRIBUTION CHART, 1999–2002



Noncommercial River Trips

Noncommercial river trips are restricted to a maximum of 16 participants, and about half reach that limit. Figure 3-5 illustrates the distribution of noncommercial motorized and non-motorized trips. The average group size for both motorized and non-motorized noncommercial trips is 13, although winter and shoulder season trips tend to be smaller. Noncommercial trips tend to have fewer people per raft, but seldom have more than eight rafts per trip.

FIGURE 3-5: NONCOMMERCIAL GROUP DISTRIBUTION CHART, 1999–2002



Type of Craft and Trip Length

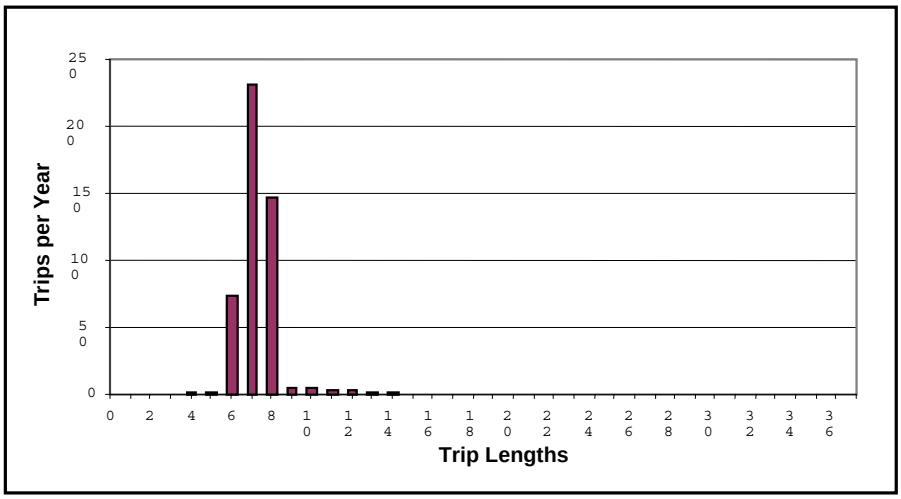
The average number of miles traveled each day varies by type of trip, takeout location, and type of craft. Based on current user-day allocations and 1999–2002 data, 63% of visitors take motorized river trips and 37% non-motorized trips.

Motorized Trips

Motorized rafts are currently allowed for three-quarters of the year (December 15 through September 15). They range in size from 22 to 39 feet, with most commercial rigs ranging 33–37 feet. They are commonly powered by 35-horsepower, four-stroke engines, although up to 55-horsepower engines are currently allowed. Large commercial motorized rafts typically have capacities of 17 to 23, and smaller motorized boats generally 8 to 15 people.

Motorized trips typically are shorter than non-motorized trips. Current regulations restrict motorized craft from traveling more than 50 miles in one day or averaging more than 40 miles per day for the entire trip. This allows most motorized trips to travel from Lees Ferry to Whitmore in six days, or Lees Ferry to Lake Mead in seven, although some trips vary. Lees Ferry to Phantom Ranch usually takes three days on motorized trips; Phantom Ranch to Whitmore takes another three days, with one more day to Lake Mead. Figure 3-6 illustrates the distribution of commercial motorized trip lengths; the most common trip length is seven days.

FIGURE 3-6: COMMERCIAL MOTORIZED TRIP LENGTH DISTRIBUTION CHART, 1999–2002

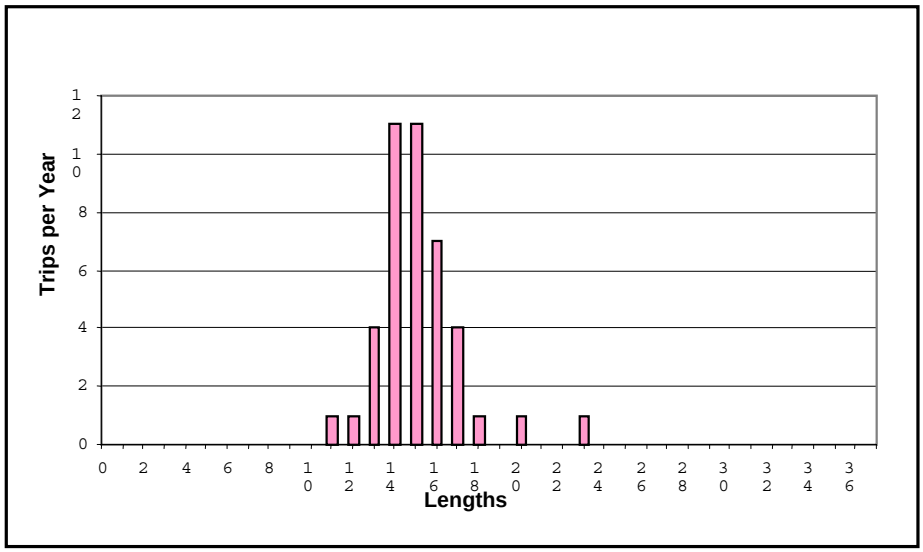


Non-motorized Trips

Non-motorized rafts are common on the river; they range from 14 to 20 feet long and carry one to six people plus gear. Most rafts are propelled by oars, although some are rigged for paddlers. Other common non-motorized craft include dories, kayaks, and catarafts.

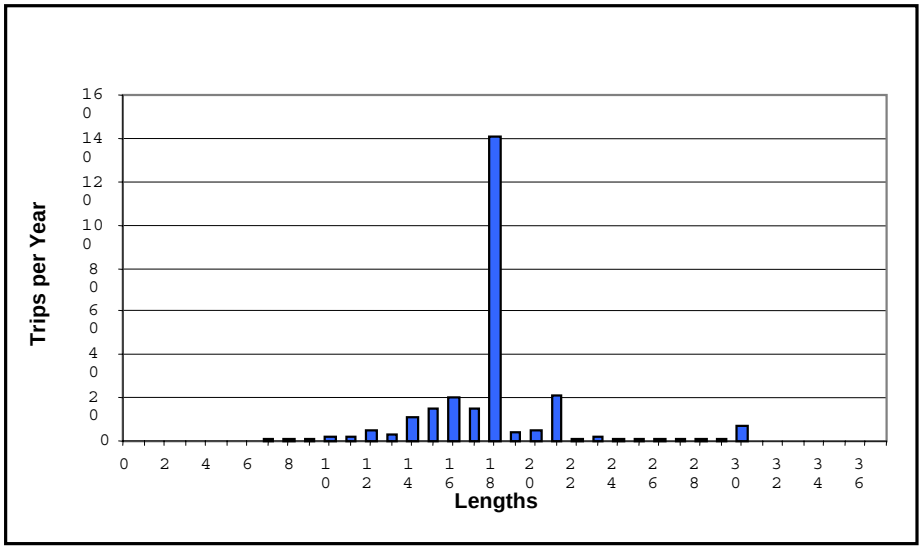
Non-motorized trips from Lees Ferry to Diamond Creek generally run 12 to 18 days; partial canyon non-motorized trips from Lees Ferry to Phantom Ranch are usually 6 to 7 days, with the partial canyon trip from Phantom Ranch to Whitmore/Diamond Creek taking slightly longer. Figure 3-7 illustrates the distribution of commercial, non-motorized trip lengths. Most commercial oar trips are 14 to 15 days long and tend to be shorter than noncommercial trips.

FIGURE 3-7: COMMERCIAL NONMOTORIZED TRIP LENGTH DISTRIBUTION CHART, 1999–2002



As illustrated in Figure 3-8, most noncommercial non-motorized trips are 18 days in length. In the shoulder and winter seasons, maximum trip length restrictions are relaxed to 21 days and 30 days respectively. These longer trips (which are usually noncommercial) average fewer miles per day or more layovers, where they stay at a single camp for more than one night. Commercial oar trips rarely lay over.

FIGURE 3-8: NONCOMMERCIAL TRIP LENGTH DISTRIBUTION CHART, 1999–2002



Seasonality

Different types of river trips are offered during different times of the year due to the current user-day allocation system, which allocates user-days by primary and secondary seasons separately for each sector. As shown in Table 3-11, commercial motor trips occur primarily in the four summer months (with the highest numbers in June and July); commercial oar trips also primarily occur in the four summer months, but some are also taken in the early fall (the first part of the non-motorized season).

TABLE 3-11: COMMERCIAL AND NONCOMMERCIAL PRIMARY AND SECONDARY SEASONS

Sector	Primary Season	Secondary Season
Commercial	May 1 – September 30	October 1 – April 30
Noncommercial	April 16 – October 15	October 16 – April 15

Due to current launch limits, noncommercial trips are evenly spread through the spring, summer, and fall, with infrequent use in the winter. Trips outside the primary summer months are distinguished by their longer duration, allowing boaters to make better use of the shorter daylight hours. On long winter trips, boaters may hurry through colder, more shaded parts of the canyon and take layovers in places where there is sun.

Passenger Exchanges

Most Grand Canyon river trips begin at Lees Ferry (RM 0) and take out at Diamond Creek (RM 226) or South Cove on Lake Mead (RM 295). (When lake levels on Lake Mead were high, lake travel began at Separation Canyon and the closest takeout on Lake Mead was Pearce Ferry [RM 280]. This facility is currently unusable because siltation and mudflats have made it inaccessible, and the closest lake takeout is now at South Cove. Lake Mead levels are predicted to remain low through the rest of this decade and for the duration of this plan.) Shorter trips are possible for boaters who join or leave existing trips at places other than the standard launches, such as Phantom Ranch or Whitmore. These are commonly known as "exchanges." People who travel from Lees Ferry to Diamond Creek or Lake Mead are said to have taken a "full canyon trip," while people who use one or more of the exchange locations have taken "partial canyon trips."

About 60% of all boaters in recent years have taken full canyon trips, although the proportion is higher among noncommercial boaters (about 80%). The largest proportion of exchanges occur at Phantom Ranch (RM 88; boaters typically hike in or out from the South Rim) or by helicopter at Whitmore (RM 187). Other hike-in/out exchange locations for noncommercial boaters include Soap Creek, South Canyon, Nankoweap, Tanner, Hance, Hermit, Boucher, Lower Bass, Tapeats, Deer Creek, and Havasu.

Most commercial passengers join Grand Canyon river trips at Lees Ferry and leave trips at Whitmore, where nearly all boaters shuttle in or out via helicopter (although there is a hiking option on a 1.3 mile trail). Some trips take passengers out to Lake Mead by jetboat from Separation Canyon, as illustrated in Figure 3-9 and Figure 3-10.

FIGURE 3-9: WHERE COMMERCIAL PASSENGERS JOINED RIVER TRIPS, 1999–2002

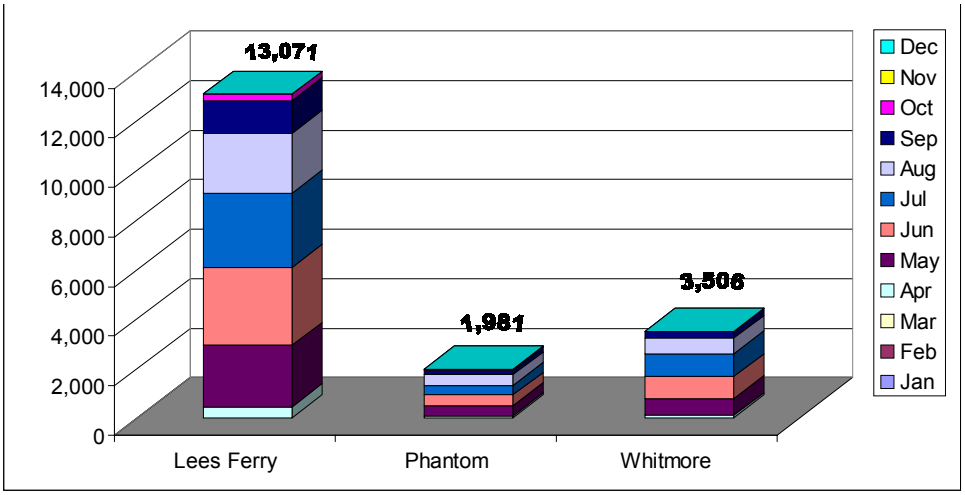
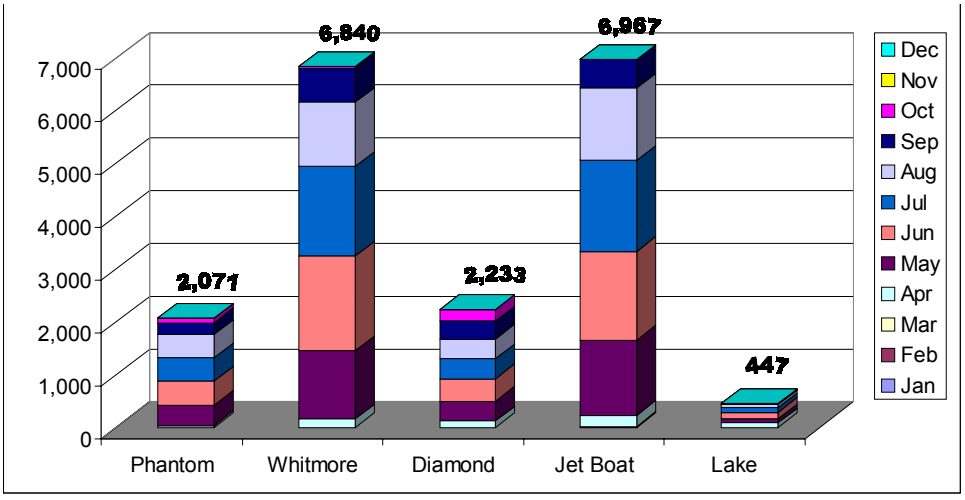


FIGURE 3-10: WHERE COMMERCIAL PASSENGERS LEFT RIVER TRIPS, 1999–2002



RIVER TRIP CHARACTERISTICS

Within-Group Social Interaction

Trips create extended time for participants to be together, providing numerous opportunities for social interaction to share challenges, develop skills, and feel exhilarated. Commercial guides and noncommercial trip leaders have the potential to facilitate social interactions, as well as provide opportunities for people to develop outdoor skills and learn about the canyon. Group dynamics also require sharing a diversity of chores and logistics on Grand Canyon river trips.

Daily Logistics and River Practices

Boaters carry in and prepare all meals on their trips; they also carry out all their refuse and solid human waste. Relatively elaborate systems and equipment have been developed to improve menus, increase efficiency, or minimize impacts. Researchers and commercial trips pioneered many of the systems that have become increasingly used by noncommercial boaters as well, since similar equipment can be rented.

Swimming

Due to cold temperatures of 48°F, river runners only spend brief periods of time swimming in the mainstem of the Colorado River. In contrast, tributaries such as the Little Colorado River, which have much warmer water temperatures, are especially inviting to swimmers. Swimming also occurs at other popular attraction sites, such as Elves Chasm, Deer Creek, and Havasu.

Fishing and Birding Opportunities

Fishing opportunities (with an Arizona state nonnative fishing license and a trout stamp) for non-native species (e.g., rainbow and brown trout) may occur throughout the Colorado River corridor, with most success above the Little Colorado River. Birding enthusiasts have opportunities throughout the entire length of the river corridor because the dense margin of riparian vegetation provides habitat for resident and tropical migrant populations.

Day Hikes

Day hikes from camps or attraction sites are highlights of many Grand Canyon river trips. Many boaters take hikes every day of their trip, and nearly all boaters do at least some hiking. Several guidebooks list numerous hikes that are available along the river corridor.

Sightseeing and Attraction Sites

Most trips stop at one to two attractions each day. These sites tend to offer good hiking, swimming, scenery, or natural, historical, or archeological features. About 30 to 40 well-known sites are regularly visited. The most popular are Redwall Cavern, Little Colorado River, Elves Chasm, Deer Creek, and Havasu; and they tend to become crowded (over 150 people at one time) during the summer. At least another 100 sites are used less frequently. The average stay across all attraction sites is about an hour, although some sites average stays of two to three hours, and some trips stay at some sites for the better part of a day. Guidebooks offer extensive descriptions of potential attraction sites and their features.

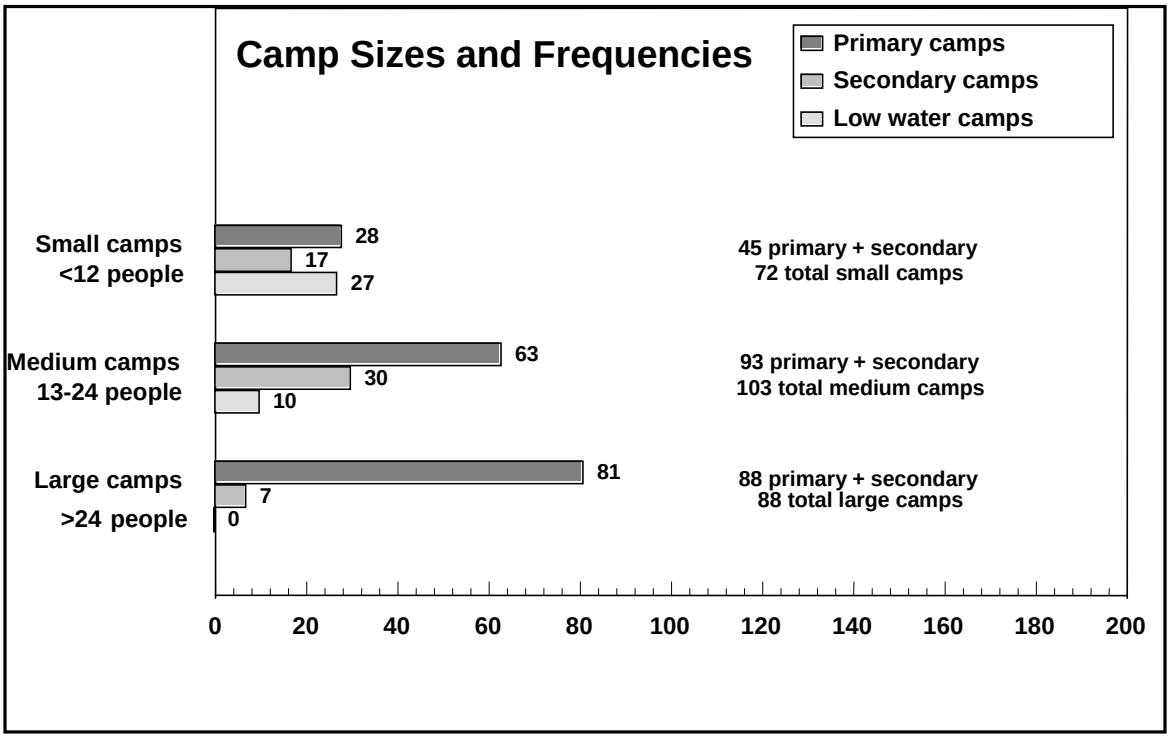
Camping

Camping occurs on undeveloped beaches. Although the number and size of beaches have decreased since Glen Canyon Dam was built in 1963, there are currently over 200 consistently identifiable beaches in Zone 1. The precise number varies from year-to-year and may depend on recent water level regimes (including experimental floods to maintain or rebuild beaches); vegetation changes; erosion from tributary flooding, wind, or recreation use; or regulations that prevent use of some camps with sensitive cultural and natural resources. Most campsites have sandy areas for "kitchens" and sleeping pads. Highly desirable sites are those with large open areas, shade, and space to moor boats (see "Campsite Distribution Poster").

Not all camps can handle the range of group sizes that currently travel the river corridor. Recent campsite inventories and researchers (Kearsley and Warren 1993; Kearsley, Schmidt, and Warren 1994; Kearsley 1995; Kearsley and Quartaroli 1996; Kaplinski et al. 2002; Thompson 2002; and Brown and Jalbert 2003) have developed three general categories — small camps (1 to 12 people); medium camps (13 to 24 people); and large camps (25 or more people). The 1993 inventory further divided camps into "primary," "secondary," and "low-water" camps (Kearsley and Warren 1993). Using a list of qualitative criteria (e.g., proximity to attraction sites, availability of shade, boat mooring qualities), primary camps were defined as having more positive than negative attributes and were used more consistently than secondary sites (defined as those

with more negative than positive attributes). Low-water camps are available only at flows below 15,000 cfs. Figure 3-11 illustrates the number of small, medium, and large sites by primary and secondary classifications, as well as the number of low-water camps in 1993.

FIGURE 3-11: NUMBER OF CAMPS BY SIZE AND TYPE — LEES FERRY TO DIAMOND CREEK



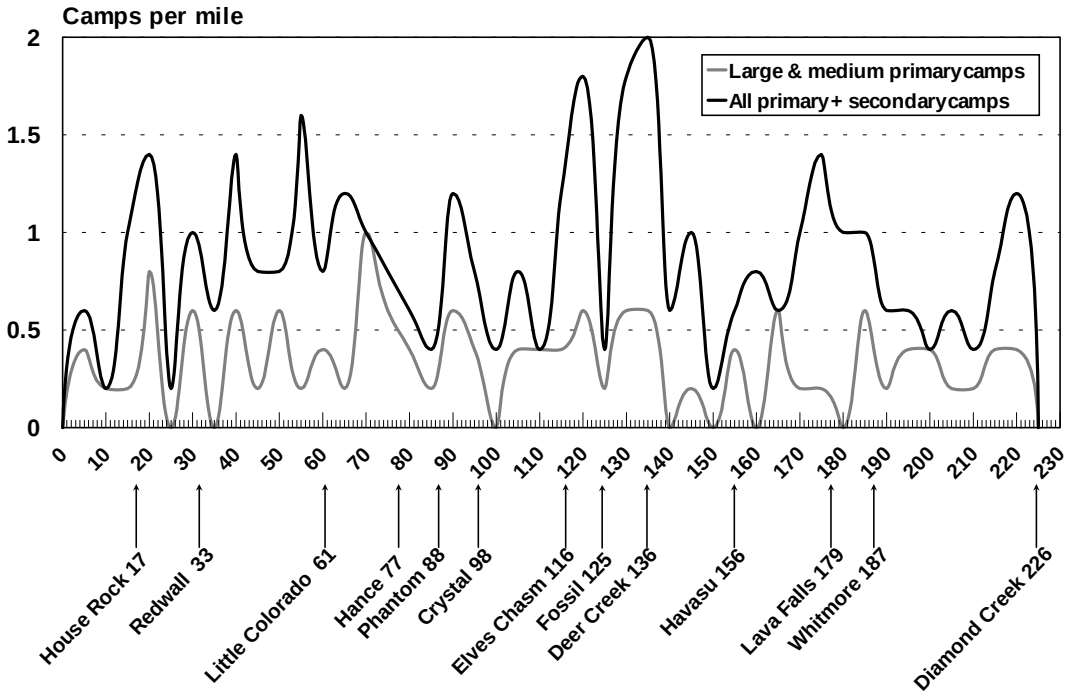
Source: Kearsley and Warren 1993.

A recent unpublished beach inventory from the Grand Canyon National Park Science Center identified 214 campsites between Lees Ferry and Diamond Creek (Brown and Jalbert 2003). Of the 214 campsites, only 55 were considered large enough to accommodate 36 people, 106 beaches could accommodate up to 24 people, and 53 could accommodate 12 or fewer.

Camp Distribution, Critical Reaches, and Bottlenecks

Over three-quarters of the camps available at all water levels are primary sites, but these campsites are not distributed uniformly throughout the canyon. Figure 3-12 illustrates the number of camps per mile from Lees Ferry to Diamond Creek (the densities were calculated for 5-mile increments for large and medium primary camps, and all primary plus secondary camps together). The figure also shows there are some reaches of the river where campsite densities are relatively lower, and where large and medium-sized primary camps are particularly scarce. These have been identified as "critical reaches," which typically correspond to narrower, gorge-like segments that have higher velocities during floods (Kearsley, Schmidt, and Warren 1994; Kaplinski et al. 2003).

FIGURE 3-12: NUMBER OF CAMP TYPES PER MILE — LEES FERRY TO DIAMOND CREEK

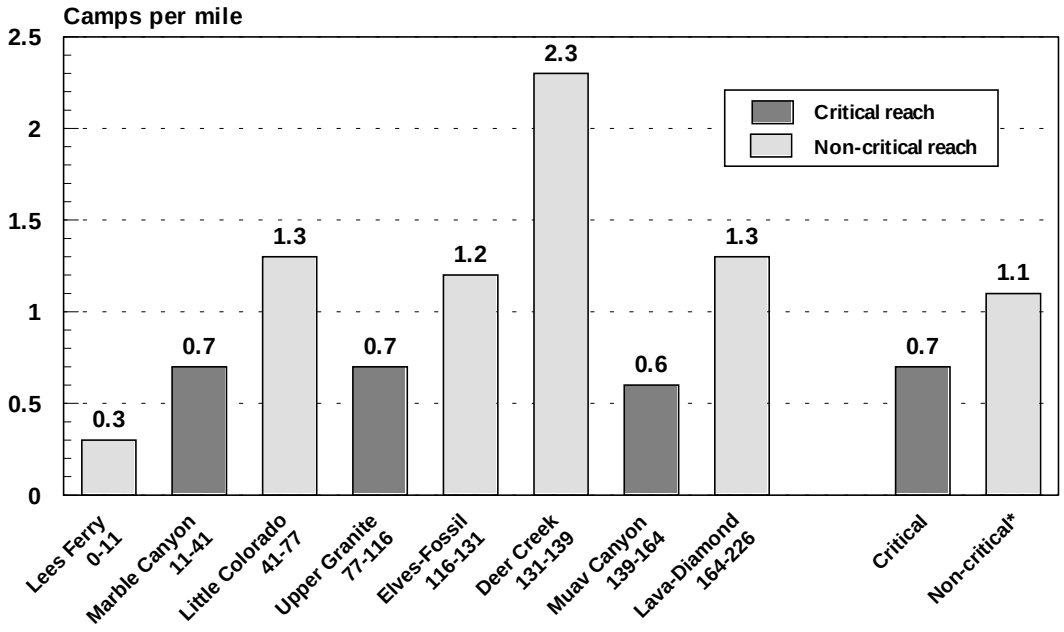


SOURCE: Adapted from Kearsley and Warren 1993, by summing camps per 5-mile increments.

Figure 3-13 illustrates campsite densities (camps per mile) in critical and non-critical reaches from Lees Ferry to Diamond Creek. For example, in non-critical reaches, there may be an average of five or six camps per 5 miles (about an hour's float), and over half of those are likely to be medium or large primary sites. In critical reaches, there may be three sites in 5 miles, with only one that can handle larger groups.

In these critical reaches, which are 25 to 40 miles long, competition for the few high-quality camps is sometimes a source of visitor conflict. No low-water camps are large enough to accommodate groups over 24, and only 10 can accommodate groups larger than 12. Brown and Jalbert's data (2003) showed that some critical reaches contain only one or two large beaches. These are Reach 2 (RM 11.3–RM 22.6), which contains only two large beaches, and Reach 9 (RM 139.9–RM 159.9), which contains only one large beach. Most of these camps are small sandbars with little shade or other positive attributes. Trip scheduling and the position of specific attraction sites further exacerbate camp competition in these reaches, creating "campsite bottlenecks." Bottleneck issues occur at specific, well-known campsites adjacent to major attraction sites, such as the Little Colorado River, Phantom Ranch (especially for trips involving exchanges), Elves Chasm, Deer Creek, Havasu, and Lava Falls. Trips prefer to be upriver of these locations for early morning arrivals, to allow exchanges to begin hiking before the heat of the day, or to maximize time at the attraction site and be able to find a new camp shortly after leaving.

FIGURE 3-13: NUMBER OF CAMPS BY TYPE PER MILE — LEES FERRY TO DIAMOND CREEK



*** Excludes Deer Creek reach.**

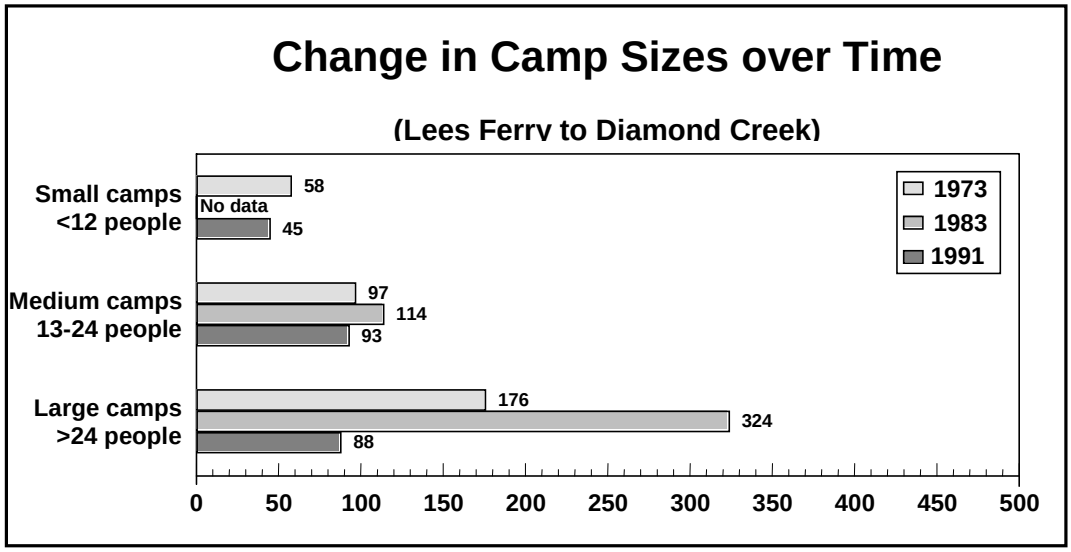
SOURCE: Adapted from Kearsley and Warren 1993.

Trends in Numbers and Sizes of Camps

The most important finding regarding beaches and camps in Grand Canyon is that they are getting smaller and less abundant. Glen Canyon Dam has depleted the canyon of important sediment sources; limited the frequency, duration, and regression of high flow events that periodically created, maintained, and cleaned beaches of encroaching vegetation; and increased erosion through daily peaking (see Figure 3-14). The highest number of camps (particularly large camps) existed during the inventory conducted immediately following the 1983 flood. By contrast, the 1991 inventory shows 75% fewer large camps than in 1983 and almost 20% fewer medium sized camps. Compared to 1973, there are about half as many large camps and a third less total camps.

More specific studies of flow regime effects on individual beaches suggest complex relationships between flows and erosion, beach building, maintenance, or cleaning (Kearsley and Warren 1993; Kearsley and Quartaroli 1997; Kearsley, Quartaroli, and Kearsley 1997). Depending on the timing, size, duration, and regression of high flow events (as well as sediment inputs from tributaries), some camps erode while others are built or replenished (at least for a short time). Studies also generally suggest that camps in critical reaches are more likely to contract or disappear because of erosion, while camps in non-critical reaches are diminished by a combination of erosion and encroaching vegetation. Research has also shown that long-term campsite loss has been most acute in critical reaches (Kearsley, Schmidt, and Warren 1994; Brian and Thomas 1984).

FIGURE 3-14: NUMBER OF CAMPS OF DIFFERENT SIZES — 1973, 1983, AND 1991



SOURCE: Weeden et al. 1975; Brian and Thomas 1984; Kearsley and Warren 1993.

Several experimental beach maintenance, beach-building, and modified peak flow regimes have been implemented to slow or reverse the diminishing beach problem (USDI 1995, 1996), so far without long-term success (Kearsley and Quartaroli 1997; Kearsley, Quartaroli, and Kearsley 1997; Kaplinsky et al. 2001). While some experimental high flows have re-created new beaches, they have also eroded others (often in critical reaches) or simply replenished beaches with new sand without substantially changing their size or usable area. Many of the gains in campable area from these flow events were eroded within a year by peaking regimes.

Future beach-building or maintenance events are planned to coincide with times when tributaries are providing higher sediment loads (through the Glen Canyon Dam Adaptive Management Program). Even if these prove more successful than past efforts, Grand Canyon beaches are unlikely to become as frequent or as large as they were before Glen Canyon Dam or shortly after the 1983 flood. Campsite capacities and availability are a major issue for recreational users, who have been adapting to smaller, less frequent, or less inviting beaches and camps since the last high water event in 1983.

FACILITIES

There are few facilities in Zone 1 of the Colorado River corridor, except for major launch areas. Brief descriptions of these facilities are provided below.

Lees Ferry

Lees Ferry (RM 0), the primary put-in at the start of a Grand Canyon river trip, has a large ramp, parking, a nearby camping area, and an information kiosk where pre-trip logistics and informa-

tion sessions are conducted. The area can become congested at high use periods (up to nine launches or 166 people launching per day).

Phantom Ranch

Phantom Ranch (RM 88) is a collection of cabins, a small store, an NPS ranger station, and campground on river right. Cabin rentals and campground sites are made by reservation. River trips are prohibited from camping at Phantom Ranch, but it is a popular exchange location. Boaters also have the option of leaving from or arriving at Phantom Ranch (or having their personal gear hauled out) by mule trains. Phantom Ranch is accessible by the Kaibab and Bright Angel trails and associated footbridges across the river. These trails offer access to the developed areas of the park on the North and South Rims. The 7-mile 5,000 vertical feet walk up the Kaibab Trail to the South Rim takes the average hiker at least 5 to 6 hours; the walk down takes about 3 to 4 hours. The 9-mile Bright Angel Trail to the South Rim usually takes the average hiker slightly longer, but has a milder gradient. During hot summer days, fatigue or heat-related conditions can affect boaters hiking out of the canyon, often requiring search-and-rescue responses from NPS rangers.

Whitmore

Whitmore (RM 187) is on Hualapai land (river left) and consists of a boat tie-up area and nearby helicopter landing pad. It is used by commercial trips as an exchange location for passengers to begin/end their river trip, with a 6-minute helicopter flight to/from the Bar-10 Ranch. (As described under "Socioeconomic Conditions," the Bar-10 Ranch provides river runners with a pre- and post-trip base for helicopter transport in and out of the canyon.) Passengers also have the option of hiking up Whitmore Wash (river right) to the rim on a 1.3 mile, 1,200 vertical feet trail. The hike up Whitmore Wash takes the average hiker less than an hour (less than 30-minutes coming down), but is generally hot because of the surrounding lava rock and little shade. This trail offers access to the Bar-10 Ranch via a 9-mile, unimproved road. The drive from the rim to the ranch takes less than an hour, but no vehicle/mule shuttle currently exists (helicopter shuttles started in 1985, replacing a mule/bus ride concession that had existed since the mid-1970s).

Diamond Creek

The Diamond Creek takeout (RM 226) is in the Area of Cooperation and is operated by both the National Park Service and the Hualapai Tribe. There is a gravel ramp area and a limited parking lot. The Hualapai Tribe owns and maintains the rough 18-mile road that traverses Diamond Creek through Hualapai land to U.S. Highway 66 at Peach Springs. Occasional wash-outs along the road can cause delays, and it typically takes about 1 to 1.5 hours to drive out of the canyon.

Diamond Creek is also the launch site for commercial trips through the Lower Gorge offered by HRR. Because of launch/takeout congestion, the Hualapai Tribe has recently requested that all commercial and noncommercial trips not use the ramp between 7 A.M. and 10 A.M. so that HRR may use the ramp to launch their trips.

VISITOR CHARACTERISTICS

It is difficult to profile the "average" Colorado River runner. Research has examined differences between the three boater groups (commercial oar passengers, commercial motor passengers, and noncommercial users), finding some useful distinctions summarized below. Within these categories, however, individuals may vary from the group profile, and some boaters take more than one type of trip over the course of their river running history. (More detailed information is available in Shelby and Neilson 1976; Bishop et al. 1987; Hall and Shelby 2000; Stewart et al. 2000, Jonas 2002.)

- *Gender, Age, and Marital Status* — In general, about 60% of Grand Canyon boaters are male, with slightly higher male-to-female ratios on noncommercial trips. About 25% of all boaters are single. There is some evidence that these ratios are becoming equalized over time. The average age of boaters has slightly increased over the past three decades from about 30 to the low 40s, probably mirroring the nation's aging population trend. Grand Canyon trips are taken by people of all ages, from young children to elderly adults, although most are between the ages of 20 and 50. There are few statistical age differences between the three boating groups (commercial oar passengers, commercial motor passengers, and noncommercial users).
- *Education* — Grand Canyon boaters tend to be better educated than the national average; about three-quarters have college degrees; and over one-third have advanced degrees. Educational differences between boater groups are generally small.
- *Income* — Grand Canyon boaters as a whole tend to have higher household incomes than the national average, with some substantial differences between groups. While only about 25% of the national population has income greater than $70,000, multiple studies show 66% to 75% of commercial passengers are in this category. In contrast, 43% of noncommercial boaters have incomes over $70,000.
- *Previous Boating Experience* — There are substantial differences between commercial passengers and noncommercial boaters regarding river-running experience. In recent years, 86% to 96% of noncommercial boaters have taken more than three previous trips on other rivers compared to 24% to 44% of commercial passengers. About 24% to 33% of commercial boaters have never taken a previous river trip; this is true for less than 6% of noncommercial boaters. About 81% of commercial passengers have never taken a Grand Canyon trip, compared to 39% of noncommercial boaters (Hall and Shelby 2000). Experience levels on other rivers and in Grand Canyon have been increasing in the past three decades. In 1975, 70% of noncommercial boaters were on their first Grand Canyon trip, compared to 39% in 1998. Among commercial passengers, this change has been less dramatic. About 90% of commercial passengers were on their first Grand Canyon trip in 1975 compared to 80% in 1998.
- *Residency* — Grand Canyon boaters come from across the country, with higher proportions of commercial passengers living farther away. Over 75% of noncommercial boaters live within 1,000 miles of the river, compared to about 45% of commercial passengers. Less than 5% of commercial motor passengers reside outside the United States, compared to less than 1% of commercial oar or noncommercial boaters.

- *Recreation Preferences* — In general, Grand Canyon boaters prefer to recreate in backcountry areas with fewer facilities and services (Hall and Shelby 2000). However, there are some interesting differences between boater types. For example, noncommercial boaters report more interest in activities, such as mountain climbing, backpacking, and hiking steep trails, than do commercial passengers. Commercial motor passengers report more interest in resorts, cruises, and hiking easier trails than oar passengers, while non-commercial boaters report considerably less interest in these activities.
- *Reasons for Taking Grand Canyon River Trips* — Boaters' reasons for taking Grand Canyon river trips are related to the unique attributes of Grand Canyon (as listed above in the "Recreation Values" section of this chapter). The most important reasons for all groups were "to see the canyon from the river" and "running exciting whitewater" (over 80% reported that these were very important). "Being in a wilderness setting" was very important to more noncommercial boaters (80%) than commercial passengers (59% to 64%). Just over half of all boaters thought "being with friends/family" was very important, while over a third thought "escaping the pressures of work or family" was very important. "Meeting new people" was very important for less than 20% of all boaters.
- *Reasons for Choosing Commercial Trips* — Most commercial passengers considered only one concessioner before selecting their trip. The most important factors considered were the length of trip, the time of trips, the type of boat, and the number of opportunities to hike or explore. The type of boat and availability of hiking were more important to oar than motor commercial passengers. Less important factors for all commercial passengers included food menus, equipment, quality of the guides, and availability of "special interest" features (possibly because people consider these similar among different companies).

HISTORY OF USE AND RECREATIONAL DEMAND

Prior to the implementation of user-day limits in the early 1970s, river use in the Grand Canyon was growing at an exponential rate (see Figure 3-15). After user-day limits were implemented, concessioners and noncommercial boaters took advantage of new exchange opportunities (at Phantom Ranch or Whitmore Wash) and generally increased the speed of their trips. This allowed them to accommodate more trips and users with the limited user-day allocations. Following increases in user-day limits from planning and legislative actions around 1980, the annual number of users increased.

As shown in Figure 3-16, the annual number of river users has not been static within the commercial and noncommercial sectors. However, since the late 1980s the number of river users has been relatively static for both sectors — 17,000 to 20,000 people per year for the commercial sector, and about 3,000 to 4,000 people per year for the noncommercial sector.

FIGURE 3-15: TOTAL RIVER USERS AND USER-DAYS BY YEAR SINCE 1960

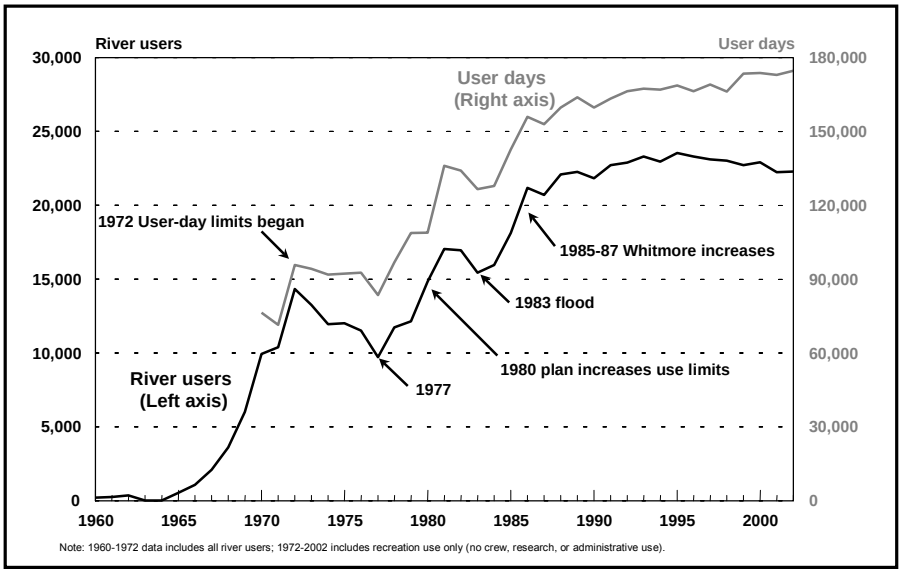
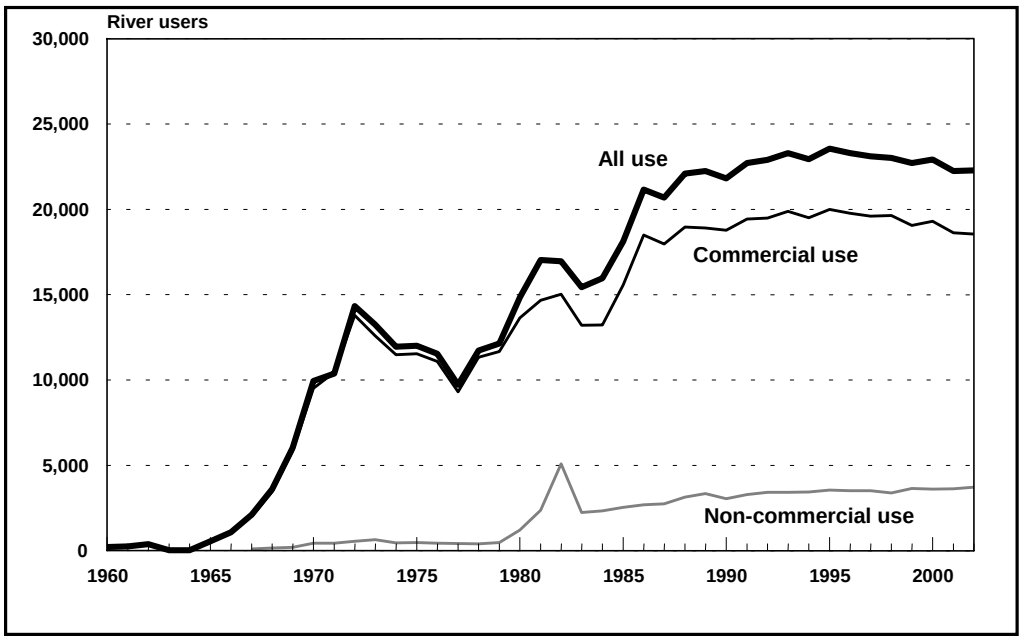


FIGURE 3-16: RIVER USERS BY COMMERCIAL AND NONCOMMERCIAL SECTORS SINCE 1960



Note: 1972–1979 data only includes people leaving Lees Ferry and no exchange information. 1960–72 data includes all river users; 1972-2002.

Phantom Ranch Exchanges

Based on anecdotal information, small numbers of visitors joined or left river trips at Phantom Ranch when the river running boom began in the late 1960s. Substantial numbers of people were not involved in Phantom Ranch exchanges until the late 1970s, and exchanges grew to current levels in the late 1980s. The number of Phantom Ranch exchanges has been relatively stable since 1987, when the National Park Service began keeping systematic records. In general, about 2,500 passengers join trips at Phantom Ranch each year, and a similar number exit there (1:1 exchange ratio in which only one user-day is counted against an outfitters' allocation). Prior to 1992, relatively fewer people hiked out than hiked in (e.g., as few as 1,067 in 1989). In recent years, most Phantom Ranch exchanges have involved commercial passengers (about 4,500 people per year) compared to about 600 noncommercial boaters; this accounts for about 20% to 25% of all commercial passengers, but less than 10% of noncommercial boaters.

Helicopter Exchanges

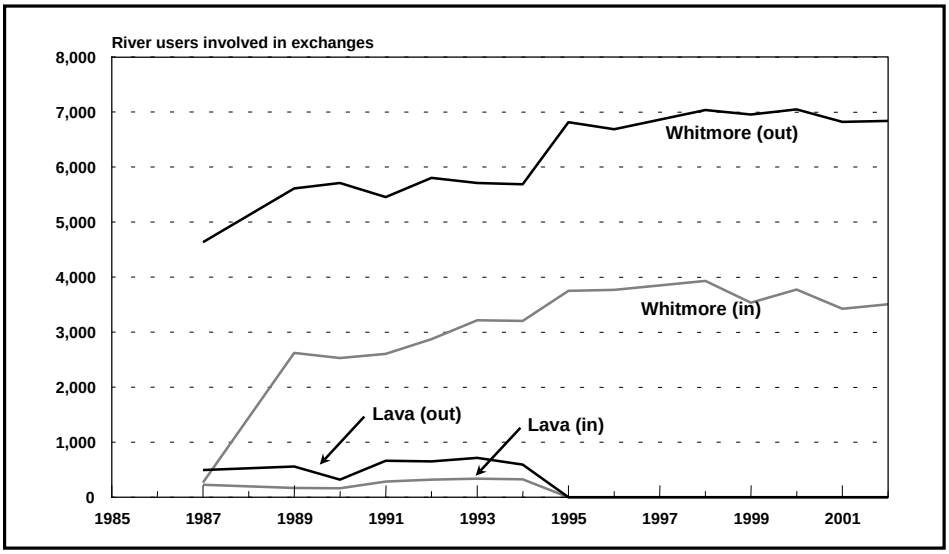
Since the early 1970s commercial passengers have entered and/or left river trips at three different locations — (1) Lava Falls (RM 179), which was used in the early 1970s; (2) a few miles downstream from Lava Falls (about RM 183), which was active from the late 1970s through 1994; and (3) Whitmore Wash (RM 187) on Hualapai land, which is still active. A mule concession operated by the Bar-10 Ranch since the mid 1970s shifted to helicopter shuttles in 1985. (Specific numbers of passengers who left the canyon at Whitmore by mule are not available, although information from the Bar-10 Ranch website suggests it was about 1,000 people per year.)

Figure 3-17 illustrates the number of passengers using the Lava Falls area and Whitmore helipads from 1987 to 2002. Helicopter use from the Lava Falls area was always relatively low (less than 500 people leaving and less than 300 entering per year), but Whitmore use was substantial from the start of the "helicopter era" in the early 1970s. Nearly 5,000 commercial passengers took-out at Whitmore in 1987; in recent years close to 7,000 commercial passengers per year take out there, which is over half of all commercial passengers putting in at Lees Ferry. Unlike Phantom Ranch exchanges, fewer passengers join trips than leave them at Whitmore.

General Demand for River Trips

Multiple sources indicate that demand exceeds supply for both commercial and noncommercial trips in the Grand Canyon. Concessioners report that they turn away prospective users because their trips are full, and some maintain informal waiting lists for those interested in future trips. Pricing also helps balance supply and demand for commercial permits, although concession contracts impose some constraints on trip prices (See "Socioeconomic Conditions" for more information).

FIGURE 3-17: HELICOPTER USE IN LAVA / WHITMORE AREA, 1987 – 2002



NOTE: No data available for 1988.

On the noncommercial side, the long waitlist clearly indicates demand exceeds supply, but for several reasons, it does not provide an accurate or reliable indicator of exact demand:

- Since huge lists, long wait times, fees, and restrictive rules tend to discourage interested applicants from applying, it is reasonable to assume true demand for noncommercial trips may include many who are not on the waitlist.
- Huge lists and long wait times also encourage some people who "could" want to go in the future to apply "just in case." This category typically would include babies and very young children added to the list by their parents.
- It makes sense to define wait times as the time between when an individual decides he or she wants to go and when he or she actually gets to go. The current waitlist, however, is a "trip leader" waitlist and does not track other participants. Studies have not surveyed those who have gone on recent trips to determine how long they waited.
- Over the last few years reports from the park's River Office have shown that a high percentage of waitlist participants who get the chance to participate in initial scheduling choose not to schedule and opt to wait one or more additional years. Thus, the un-answered question is how many want to go in any one year or shorter time frame.
- The current waitlist represents trip leaders who at least "may" want to go sometime in the future. This could mean right away, in the next few years, in 10 years, or sometime in the next two to three decades.

Despite all the difficulties and challenges, prospective trip leaders have steadily joined a waitlist for permits for over the last two decades. When new additions were frozen in the fall of 2003, there were over 8,200 names on the list. Since 1986, an average of about 1,000 people joined each year (as few as 458 in 1998 when fees increased and as many as 1,380 in 1995).

Even in winter there is considerable demand for noncommercial trips. For the four winters from 1998–99 through 2001–02, the park operated a "winter launch test" program that allowed waiting list members to use supplemental launches (without counting against user-day allocations). These launches were released in winter months when less than three regular launches per week were scheduled. Over 90% of the 153 launches offered through the program were used, and 100% were used when the park provided at least a six-month planning horizon. The cancellation rate for these launches was lower (14%) than for the regular permit system (42% in 2002).

LOWER GORGE (ZONES 2 AND 3)

RECREATIONAL VALUES AND OPPORTUNITIES

The 51-mile Lower Gorge offers substantially different recreation trips than upstream. While the first 14 miles are similar to the upper Grand Canyon, Lake Mead has influenced the river below Separation Canyon, presenting an unusual hybrid river/lake environment for the remaining 38 miles in the park. From the park boundary (RM 277) it is 18 miles to takeouts at Pearce Ferry (RM 280) or South Cove (RM 295) in Lake Mead.

When Lake Mead levels are high, the start of "green water" (where sediment first drops out of suspension) is near Separation Canyon. Due to drought since 1999, the lake is currently about 90 feet below full pool, and 70 to 80 feet below normal high levels. This has moved the green-water line nearly 50 miles downriver to Iceberg Canyon (about 5 miles from South Cove). Lowered lake levels have also changed the gradient of the river in this section, creating a moving current that is absent at high lake levels. Lowered lake levels have not re-exposed historical river rapids, which have been covered in silt from years of lake inundation.

The Grand Canyon and the geologic features of the Lower Gorge remain spectacular downriver of Separation Canyon, but the riparian environment is dramatically altered. The current is sluggish, beaches are fewer and smaller, and hiking opportunities are more limited. Tamarisk and arrowweed have invaded the sandy uplands (making most uncampable), and the river is currently cutting through huge silt deposits exposed by receding reservoir levels, with many former beach areas 5 to 20 feet above the water surface and difficult to reach because of steep cut banks.

There are different use patterns in the Lower Gorge. While some trips are continuations of trips that start at Lees Ferry, other trips start at Whitmore (RM 187) or Diamond Creek (RM 226) and are much shorter. Most commercial continuation trips end at Separation Canyon, where jetboats take passengers through the rest of the Lower Gorge at higher speed (while guides "deadhead" the rafts). Other commercial motor trips start at Diamond Creek and run the entire reach in a day (dropping or exchanging passengers near Quartermaster where they use helicopter shuttles).

Parts of the Lower Gorge are also used by people coming from the rim by helicopter or upriver from Lake Mead. When lake levels are high, powerboats commonly run to Separation Canyon (the current legal limit of upriver travel). At lower lake levels, shifting sandbars and some faster currents make it more difficult for larger boats or less skilled operators to navigate.

The Lower Gorge has "node" development and very high use levels in the Quartermaster area (RM 262), dramatically changing the sense of solitude and primitive nature of the canyon. Several helicopter operations offer tours from Grand Canyon West into the area, with some 200 flights per day in summer. Helicopters transport people into the canyon to connect with 20-minute motorized pontoon boat tours of the immediate area. People who have traveled from Diamond Creek on commercial motor day trips fly out on the same helicopters flights. Still others just stay a short while and then fly out.

Taken together, different recreational opportunities are offered in the Lower Gorge than in the upper canyon. In general, the Lower Gorge has shorter, less primitive trips, with a focus on scenery rather than whitewater, camping, or hiking. Still, the Lower Gorge offers some good hiking and camping, as well as opportunities for solitude in the off-summer months and shorter trips for people who want to get a sense of the canyon, but may lack time or resources for a full canyon trip.

Trip Types

Several trip types are available in the Lower Gorge (see Table 3-12), although use is not well documented compared to the upper canyon. Information is based on NPS ranger reports, limited use data, Hualapai Tribe or Lower Gorge concession operators, and field reconnaissance.

TABLE 3-12: SUMMARY OF TRIP TYPES AND ACTIVITIES IN THE LOWER GORGE

Type of Trip or Activity	Zones	Description
Continuation Trips Commercial Noncommercial	1,2,3,4	Trips launching from Lees Ferry and taking out at Lake Mead.
Trips from Diamond Creek Down Noncommercial Educational HRR Day Use Trips HRR overnight trips	2,3,4	Trips launching from Diamond Creek.
Jetboat Services	2,3,4	Commercial trip passenger transportation from Separation Canyon to Lake Mead.
Lake users	2,3,4	Power boaters, kayakers, etc., traveling form Lake Mead into the Lower Gorge.
Scenic helicopter tours	3	Tours originating at Grand Canyon West and landing on Hualapai tribal lands adjacent to river.
Pontoon boat tours	3	Short river tours originating near the Quartermaster area; passenger access is by helicopter.

Continuation Trips

Commercial Trips. Commercial trips start at Lees Ferry, but may pick up passengers from exchanges at Phantom Ranch or Whitmore; about 85% of the trips are motorized. About 80% of commercial trips (and nearly all oar trips) transfer passengers to jetboats at Separation Canyon; about 5% take passengers to South Cove, and 10% are "deadhead" trips that leave their passengers at Whitmore or Diamond Creek. (More information about jetboat takeout services is given below.)

Most continuation trips appear to spend one night in the Lower Gorge, although those not meeting jetboats may spend more. One-night trips tend to stay just below Diamond Creek, while additional nights on longer trips are generally spent below Separation Canyon. Once relieved of passengers, guides deadhead to the lake using motors.

Noncommercial Trips. About 15% of Lees Ferry noncommercial trips continue past Diamond Creek. Boaters appear to take these trips to lengthen their time in the canyon, run the additional 14 miles of river before Separation Canyon, see the full geological/historical sites in the canyon, or avoid fees associated with Diamond Creek. In rare cases, boaters take continuation trips when Diamond Creek becomes closed due to a road washout. In general, these trips appear to spend one to two nights between Diamond Creek and Separation Canyon, and (more rarely) additional nights below Separation. Most of these trips use small "kicker motors" or tow-out services, starting between Lake Mead and Separation Canyon.

Trips from Diamond Creek Down

Noncommercial or Educational Trips. Noncommercial or educational trips focus on the Lower Gorge, making them distinct from continuation trips because they are short in terms of days and miles. The National Park Service allows two launches per day from Diamond Creek year-round. In 2002, there were 100 trips (82 noncommercial and 18 educational). Group size limits are 16 for noncommercial trips and 24 for educational trips.

These trips offer a "taste" of the Grand Canyon for noncommercial boaters unable to secure a permit for a full canyon trip, and they provide educational groups (boy scouts, college programs, etc.) with shorter trip options. They may be particularly attractive in shoulder or winter seasons, because the Lower Gorge is generally the warmest part of the Grand Canyon. They are probably less attractive in mid-summer, with hotter weather and less solitude due to more continuation trips and helicopter activity.

The more attractive parts of trips are upriver of Separation Canyon, and some groups spend multiple nights or layover in this short reach. Most trips appear to spend less than three nights total in the Lower Gorge, although it is possible to spend more if boaters are interested in lake travel or off-river hiking (backcountry permits are required to camp off the river, and Hualapai tribal permits are required for access to land above the high-water mark on the left side of the river). Most trips from Diamond Creek down use kicker motors or tow-out services for travel on the lake.

HRR Commercial Motorized Day Trips. Hualapai River Runners (run by the Hualapai Tribe) offer commercial motorized day trips from Diamond Creek on 22-foot snout rigs powered by twin 25-horsepower outboards. With a capacity of 10, generally 8 passengers plus 2 crew, these boats can get "on step" and travel 15 to 20 miles per hour (noticeably faster than typical Grand Canyon motorized rafts). These trips drop passengers at RM 262 and increasingly exchange passengers rather than deadhead empty boats to South Cove. HRR sometimes deadhead boats from Diamond Creek to meet groups arriving by helicopter for a "lake" trip to South Cove. HRR currently runs 8 to 10 boats per day in summer, usually traveling together as a single launch (although spread out more than other motorized groups, which rarely exceed two boats).

HRR Commercial Motor Overnight Trips. An average of three overnight trips per month are launched from Diamond Creek. These trips, which use 10 person-capacity, 22-foot snout rigs, generally spend one to two nights in the Lower Gorge and take out via helicopter in the Quartermaster area. Group sizes are unregulated and vary somewhat, but average 24 passengers.

Commercial Jetboat Services. Many commercial continuation trips meet commercial jetboats at Separation Canyon to avoid having their passengers travel the slower river/lake miles on rafts. Jetboats displace 17–19 tons and carry between 20 and 54 passengers per trip (usually one to two raft trips per jetboat). The current jetboat concession (Canyon Jetboat Services) has four boats. The trip from Separation Canyon to South Cove takes about two hours.

Trips Originating from Lake Mead

When lake levels were high, it was common for boaters to travel upriver from Lake Mead access points (Pearce Ferry, South Cove) by means of powerboats or even sea kayaks. In recent years, only very skilled powerboat operators (usually in jetboats) appear willing to negotiate the shifting sand bars in the reach between Pearce Ferry and Separation Canyon. Limited camps below Separation Canyon discourage overnight use by these trips, but competition between upriver and downriver groups could occur if lake levels rise again. Powerboats have greater flexibility to choose sites for multiday camps on the lake.

Helicopter Tours and Pontoon Boat Operations

These scenery-oriented trips take visitors from the canyon rim to the river by helicopter in the Quartermaster / RM 262 area. Aside from Whitmore helicopter passenger exchanges, these trips, which land and take off on sovereign tribal land above the high-water mark, are the only helicopter tours in the Grand Canyon that land near the river. The short flights originate from Grand Canyon West, but visitors come to the area from as far as Phoenix or Las Vegas by fixed-wing aircraft (half day tours) or vehicle (full day tours). Tours are often packaged with other sightseeing features, including rim overlooks, Hoover Dam visits, or aerial "flight-seeing" of the lake and Rainbow Wash. Visitors appear to spend less than an hour in the bottom of the canyon, and most also take short tours on motorized pontoon boats docked at RM 262 (see below). There are shade structures at one landing site, with stairs leading down to the boat docks.

The pontoon boats are 21 to 24 feet long and carry up to 12 passengers plus crew (usually one operator/guide); they are powered by 50–60 horsepower, four-stroke engines. When lake levels are low, they typically motor upriver less than 1 mile, then return to the dock about 20 minutes later. At higher lake levels (when there is less current), they travel 1–2 miles farther. Oriental Tours, Inc. currently operates five to six pontoon boats in the Quartermaster area.

Seasonality

Currently, river trips launching from Diamond Creek are not seasonally regulated. HRR trips run from March through October. Although two noncommercial and educational trips are allowed to launch each day, these types of trips are more common in the shoulder months due to more

favorable temperatures in the Lower Gorge. Pontoon tours are conducted year-round. Currently Lower Gorge trip lengths are not limited, although a typical noncommercial trip is three to six days from Diamond Creek to Lake Mead.

Passenger Exchanges

Passengers on HRR day and overnight trips currently exit the Lower Gorge by helicopter at RM 262. Very few trips conduct passenger exchanges where people fly in and take a flat-water river trip from RM 262 to Lake Mead.

RIVER TRIP CHARACTERISTICS

Within-Group Social Interaction

Little is known about the social dynamics of Lower Gorge trips as compared to full-canyon trips. Trips are shorter and provide few opportunities for social interactions, especially one-day trips.

Daily Logistics and River Practices

Similar to upper canyon trips, boaters carry in and prepare all meals, and carry out all their refuse and solid human waste. Day use trips utilize the composting toilet at Spencer Canyon.

Swimming

Water temperatures above Separation Canyon remain too cool for leisurely swimming, but as the water transitions into Lake Mead, it becomes more inviting. At the "green water" boundary (where the current slows enough for silt to drop out suspension) the water is generally quite warm and less turbid.

Day Hikes

Day hikes are conducted from some camps and attraction sites. Many of the side canyons in the Lower Gorge were once inundated by Lake Mead. As the lake levels receded, these delta areas became overgrown with tamarisk and willows, making access to side canyon hikes difficult. Additionally, high temperatures in the Lower Gorge in summer are not conducive to hiking.

Attraction Sites

There are fewer "attraction sites" in the Lower Gorge than the main canyon, although three appear to receive regular use (Travertine Canyon, Travertine Falls, and Separation Canyon). Several other side canyons have hiking opportunities, but these are less well known, and vegetation encroachment makes access from the river difficult. Guidebooks offer more detailed descriptions of attraction sites and their features.

Camping

Camps in the Lower Gorge are limited at present, with dropping lake levels and vegetation encroachment likely to degrade the quality of existing sites in the future. Table 3-13 shows camps identified in various inventories, with currently usable camps shown in bold. Although there may have been as many as 30 identifiable camps from Diamond Creek to the park boundary in the past (including 20 below Separation), there are currently only six commonly used camps from Diamond to Separation, with another six below Separation. Depending on lake and river levels, some additional small, low-water camps may emerge on sand bars as reservoir levels drop, but these appear to become invaded by vegetation within a season or two of their appearance.

Below the park boundary, there are currently more large camps on the silt bars exposed by receding lake levels. Many of these are also suffering from rapid vegetation encroachment, but they are more expansive than those in the park, and Lake Mead rangers estimate that most will remain usable for the next few years.

TABLE 3-13: LOWER GORGE CAMPS, ATTRACTION SITES, AND FACILITIES

Camp	Zone	River Mile	Comments
Below Diamond	2	226 R	Large campsite; low use
Travertine Canyon	2	229 L	Small, rocky campsite; attraction site
Travertine Falls	2	230.5 L	Small campsite; low to moderate use; attraction site
Bridge Canyon	2	235 L	Small campsite; low use
Gneiss Canyon	2	236 R	Medium campsite; moderate to low use
Fairchild	2	236.5 L	Medium campsite; moderate use
Bridge City	2	238.5 L	Large campsite; high use (most popular camp)
Separation Canyon	2	239.6 R	Small campsite; moderate use; attraction site
RM 241 Left	2	241.5 L	Medium campsite; low use
RM 241 Right	2	241.5 R	Medium campsite; low use
RM 243 Right	2	243.1 R	Large campsite; high use
Spencer Canyon	2	246 L	Medium campsite; low use; attraction site; compost toilet
Surprise Canyon	2	248.2 R	Large sandbar at flows below 8,000 cfs
RM 253	2	253 R	Small campsite; moderate use
Burnt Springs Canyon	2	259.5 R	Medium campsite; moderate use
Quartermaster Area	3	260-263 L	High use area; helipads, shade structures, toilets, and dock
Bat Cave	3	266	Attraction site; restricted entry
Columbine Falls	3	274.3	Attraction site
Mouth of Pearce Bay	3	279	Large campsite; low use.
Pearce Bay to Iceberg Canyon	3	Lake Mead	Large sand bars at current lake levels

FACILITIES

Diamond Creek

The Diamond Creek launch and takeout area is at RM 226, at the confluence of Diamond Creek and the Colorado River, and it is managed by HRR. It has a gravel ramp area, limited parking, and a rough 18-mile road through the reservation to U.S. Highway 66. The road has occasional wash-outs where it crosses Diamond Creek. It typically takes about 1 to 1.5 hours to drive from the river to the highway. From there it is about 110 miles to Flagstaff, 230 miles to Lees Ferry, or 150 miles to Las Vegas. Takeout and launch operations are managed by HRR. The Hualapai Tribe charges fees to use Diamond Creek. Diamond Creek is also the put-in for Diamond down HRR commercial trips.

Quartermaster / RM 262 Area

There are 15 helipads in the Quartermaster area. While all of the pads offer access and egress for land-and-leave flights, the pads at RM 262 and RM 263 are also used to transport HRR and pontoon trip passengers. Facilities associated with recreation in the Quartermaster area are detailed in Table 3-14.

TABLE 3-14: DEVELOPMENT AT THE QUARTERMASTER AREA

River Mile	Helipads	Ramadas	Toilets	Docks	Comments
259	2	0	0	0	"Land and leave" only; less than 40 flights per day to these two sets of helipads.
260	4	2	0	0	
262	2	1	0	1	Pontoon boats; "land and leave;" gas storage; engine repair
263	7	3	2	1	Pontoon boats; "land and leave"
Total	**15**	**6**	**2**	**2**	

Lake Mead Takeouts

There are two relevant takeouts on Lake Mead. In previous years the majority of river trips used Pearce Ferry at RM 280, but low lake levels have made this access site unusable. When accessible, Pearce Ferry has a large boat ramp, parking, information kiosks, campground, and vault toilets.

Currently, the first usable takeout is at South Cove (RM 295). South Cove has a two large ramps (one is reserved for river runner use), parking, and restrooms. The Lake Mead takeouts are part of Lake Mead National Recreation Area.

RIVER VISITOR CHARACTERISTICS:

Little information about Lower Gorge visitors is available, but visitors on Lees Ferry continuation trips are similar to main canyon users. Some visitors on noncommercial continuation trips may seek the longest trip possible. Passengers starting at Whitmore- are typically recruited out of Las Vegas for short two- and three-day trips.

Little information is available about HRR day trip passengers or Lower Gorge helicopter users, but visitor characteristics are probably more like "general tourists" than main canyon river runners. Recruited from area tourist destinations and larger gateway cities such as Las Vegas and Phoenix, they are probably less likely to have river running and backcountry experience, or interest in longer wilderness trips.

Visitation Levels and Recreational Demand

Recreation use levels are not as closely monitored in the Lower Gorge than from Lees Ferry to Diamond Creek. Use patterns associated with HRR day trips and Quartermaster helicopter use are only approximations.

Continuation Trip Use

Data for the main canyon can be used to characterize use levels for Lower Gorge continuation trips (although the upper canyon focus is on user-days rather than trips or passengers). Figure 3-18 shows the distinct seasonality of commercial trips. Commercial use in the Lower Gorge is heaviest in summer, mirroring national vacation trends. Noncommercial use appears more evenly spread through the year, in part because the upper canyon noncommercial permit system more evenly distributes noncommercial continuation trips through the seasons and through the week.

FIGURE 3-18: MONTHLY USER-DAYS IN THE LOWER GORGE BASED ON CONTINUATION TRIP INFORMATION

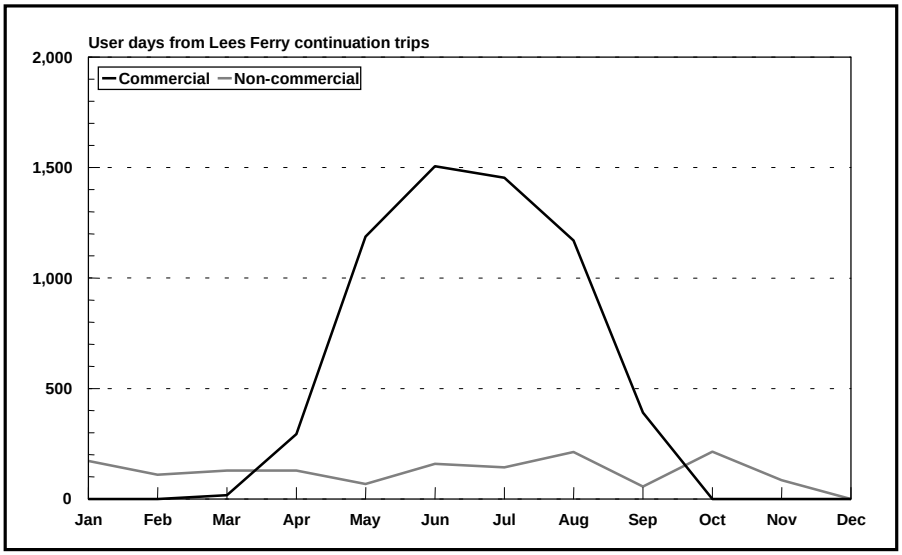
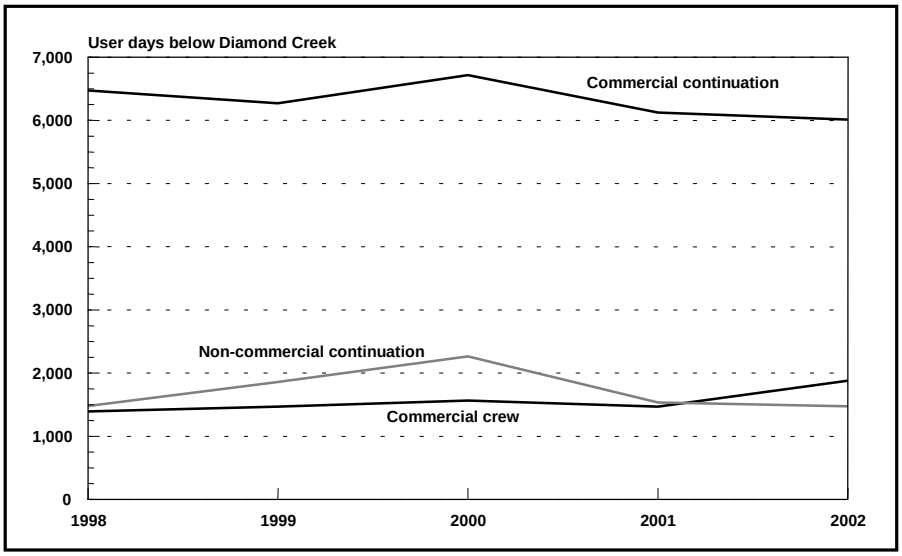


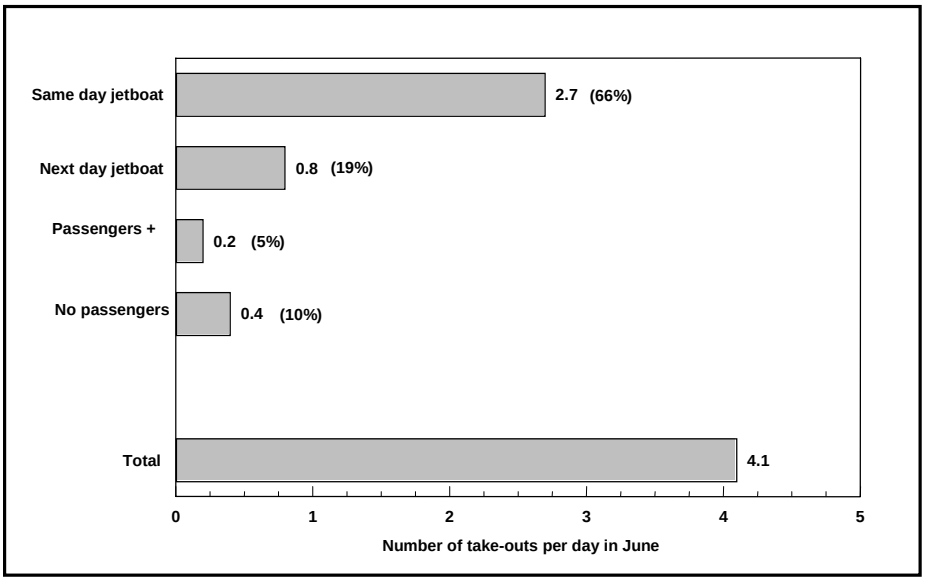
Figure 3-19 shows annual user-days below Diamond Creek for commercial passengers, crew, and noncommercial users from 1998 to 2002, when continuation trips were relatively static.

FIGURE 3-19: ANNUAL USER-DAYS BELOW DIAMOND CREEK FOR CONTINUATION TRIPS



Continuation trip takeout information for June 2002 shows average daily use levels during the peak season (see Figure 3-20). Data suggest about four trips take out on the lake per day, although only 5% involve passengers and rafts at the same time. Passengers on most trips travel out by jetboat from Separation Canyon, and rafts arrive at South Cove later. Having passengers and rafts arrive at South Cove at different times may distribute use enough to help avoid congestion problems. However, uneven takeout patterns may cause congestion on some days (e.g., Saturdays in June 2002 averaged 7.4 trip takeouts at South Cove, and Fridays only 1.5).

FIGURE 3-20: CONTINUATION TRIP TAKEOUTS ON LAKE MEAD, JUNE 2002



Noncommercial and Educational Trips Launching at Diamond Creek

About 100 noncommercial and educational trips (about 80% noncommercial and 20% educational) launch at Diamond Creek. These trips appear slightly more popular in shoulder and winter seasons when the Lower Gorge is not as hot and commercial use is lower. They may add to Lake Mead takeout congestion, particularly if they occur on a busy summer day along with commercial continuation trips (Saturdays, Sundays, and Mondays).

HRR Day Use

More than 7,000 people take HRR day trips each year, and more than 500 people take overnight trips. The great majority of trips go from Diamond Creek to RM 262, and just a few begin at RM 262. More than 80% of the usage occurs from May through September. During the summer daily usage can exceed 80 passengers, but it averages approximately 30 passengers during the entire season (currently, from mid-March through October).

Helicopter Use and Pontoon Boat Activity

More than 56,000 tourists flew to the Quartermaster / RM 262 helipads in 2003 to board pontoon boats for quick jaunts down the river, an increase of nearly 80% compared to 2002, according to

figures provided by the Hualapai Tribe. With "look-and-leave" tour visitation believed to exceed 80,000 people per year, visitation to and helicopter usage in this section of the canyon is even greater and apparently growing rapidly. Usage is high throughout the summer and shoulder seasons.

TABLE 3-15: HRR, PONTOON TOUR, AND LOOK-AND-LEAVE TOUR VISITATION ESTIMATES

Trip Type	People per Year	Helicopter Flights per Year	Percentage of Total Helicopter Activity	Comments
HRR trips	7,500[a]	1,700[c]	5%	Higher in summer.
Pontoon tours	56,500[a]	12,600[c]	40%	Higher in summer and shoulder seasons.
Look-and-leave tours	84,000[a]	19,000[b]	55%	Higher in shoulder seasons.
Total	148,000	33,300[c]	100%	May exceed 120 flights on some days.

SOURCES:
a. Hualapai Tribe estimates.
b. NPS estimates.
c. Calculated estimate based on assumptions.
NOTE:: Estimates are based on limited information; they suggest the magnitude of use rather than definitive levels.

Upriver Lake Travel

Upriver travel into Grand Canyon National Park (aside from jetboats involved with commercial continuation takeouts) has been relatively rare since the fall in Lake Mead levels. "Normal" high lake levels were last seen in summer 1999.

Demand for Lower Gorge River Trips

The demand for pontoon tours appears to be increasing rapidly, and the National Park Service believes that HRR trips and look-and-leave tours are also becoming more popular. These short, accessible trips allow casual tourists (many of whom fly in from Las Vegas) to see the Grand Canyon from river level for a relatively small investment of time, money, and effort. The demand for such tours is larger than that for longer trips on the river. Despite its short length, modified environment, and logistical challenges due to lake level impacts, the Lower Gorge is likely to see increased use in the future as it becomes better known as a trip option.

Similarly, HRR day trips and Quartermaster helicopter tours are also likely to see increasing demand. These accessible, short trips allow casual tourists to see the Grand Canyon from river level for a relatively small investment of time, money, or effort, and the population interested in such a trip is larger compared to those who would consider a longer trip.

SOCIOECONOMIC CONDITIONS

This section describes the socioeconomic conditions of the area impacted by the recreational use on the Colorado River through Grand Canyon National Park.

AREA OF ANALYSIS AND AFFECTED POPULATIONS

The affected environment includes three distinct economies and populations: (1) regional and local, (2) river runners, and (3) river tour operators. The affected areas consist of Grand Canyon National Park (primarily in Coconino County and partly within Mohave County, Arizona) and the primary gateway communities within 80 miles (or about an hour and a half driving time from the park). This section focuses on the economy generated by the river rafting industry in the Grand Canyon and places it within the context of the region's economy.

The affected environment includes the primary gateway communities to Grand Canyon National Park: Flagstaff, Williams, Cameron, Page, Marble Canyon, Fredonia, Jacob Lake, Bodaway / Gap, and Havasupai (all in Coconino County, Arizona) and the bordering communities of Peach Springs, Arizona (Mohave County), Seligman, Arizona (Yavapai County), and Kanab, Utah (Hjerpe and Kim 2003).

The total population of the affected region in 2000 was 126,546 (Table 3-16). The affected region experienced a population increase of 25% from 1990 to 2000 (U. S. Bureau of the Census 1990, 2000). The increase in population for the affected region is higher than the national population increase of 13% for the same time period, yet lower than the increase of 40% recorded by the entire state of Arizona from 1990 to 2000 (U. S. Bureau of the Census 2000). Individually, the population of Coconino County increased by 24% from 1990 to 2000, the town of Kanab, Utah, by 8%, and the population of Peach Springs, Arizona, decreased by 25%. The decrease in population for Peach Springs can be attributed to residents searching for improved economic opportunities outside the Hualapai Reservation.

REGIONAL AND LOCAL ECONOMIES

Employment figures available for the affected region include all waged, salaried, and self-employed positions (Table 3-17). Total employment in 1999 was about 57% of the population. Of the total employment of 71,558, retail trade accounts for the largest share (21%). Local unemployment rates ran higher than the national average. While the national unemployment rate was 4%, the comparable rate in Flagstaff was 4.5%, Coconino County and Kanab ran between 5% and 6%, and the unemployment rate was highest in the Peach Springs area, at 7.7% (U. S. Bureau of the Census 2000).

Table 3-17 shows the total personal income for the region. Total personal income is from employee compensation, proprietor income, other property income, and indirect business tax. Retail trade and real estate each account for approximately 14% of the total income for the

TABLE 3-16: POPULATION OF MAJOR COMMUNITIES WITHIN THE GRAND CANYON AFFECTED REGION

Community	1990	2000	Percentage of Total (2000)
Bodaway / Gap	NA	2,125	1.7
Cameron	495	978	0.8
Flagstaff	45,857	52,894	41.8
Fredonia	1,197	1,036	0.8
Supai	433	503	0.4
Leupp	954	970	0.8
Page	6,598	6,809	5.4
Tuba City	7,323	8,225	6.5
Williams	2,461	2,842	2.3
Unincorporated	31,273	43,544	34.4
Coconino County Total	**96,591**	**119,926**	**94.8**
Peach Springs, Arizona	801	600	0.5
Seligman, Arizona	300	456	0.4
Meadview, Arizona	NA	2,000	1.6
Kanab, Utah	3,289	3,564	2.8
Total	**100,981**	**126,546**	**100.0**

Sources: 1990 data — U.S. Bureau of the Census 1990.
2000 data — U.S. Bureau of the Census 2000.
Newel (2004).
NA = not available.

region. Economic output of the region by industrial sector is also shown in this table. Construction, retail trade, and real estate are the sectors with the largest outputs.

TABLE 3-17: EMPLOYMENT, INCOME, AND OUTPUT BY INDUSTRIAL SECTOR FOR THE GRAND CANYON AFFECTED REGION

Aggregated Industrial Sector	Total Employment	Total Income (Millions of Dollars)	Total Output (Millions of Dollars)
Retail Trade	15,260	$445.3	$606.0
Education	8,012	$277.5	$277.5
Real Estate	2,083	$437.3	$596.6
Health Services	5,985	$279.8	$438.8
Construction	5,124	$198.8	$638.6
Hotels and Lodging Places	5,014	$173.6	$257.5
Federal non-military	4,840	$260.9	$266.5
State and Local Government (non-education)	3,729	$196.2	$228.8
Other Sectors	21,511	$846.4	$1,847.0
Total	**71,558**	**$3,115.8**	**$5,157.3**

Source: IMPLAN Professional Analysis Guide (1999) for Coconino County, Arizona; Peach Springs, Arizona; and Kanab, Utah.
Notes: 1999 figures adjusted to 2003 dollar terms using "Consumer Price Index, All Urban Consumers" (Bureau of Labor Statistics 2003).

COMMUNITIES

The communities most likely affected by alternatives presented in this document include Marble Canyon, Flagstaff, and Peach Springs/Hualapai Reservation. Other communities such as Page and Seligman, Arizona; Kanab, Utah / Fredonia, Arizona; and Las Vegas, Nevada, receive more indirect social and economic impacts from river rafting in the Grand Canyon. Based on prior

analysis by Hjerpe and Kim (2003), Las Vegas was not included because the direct economic spending from river runners is considered too small (especially compared with other local economic activities) to have any discernible influence on the city's economy of more than $2.4 billion. Along with the surrounding communities, the Bar 10 Ranch and its operations are also discussed. The following provides a brief overview of the local communities within the affected region and their key relationships with river rafting in the Grand Canyon.

Flagstaff, Arizona

Flagstaff (population approximately 53,000) is the largest city in the region. It is a major transportation hub and a residential and commercial center for the area. As a result, many Grand Canyon boating groups gather in Flagstaff before the start of their river trip. Five of the Grand Canyon river rafting concessioners are based in the Flagstaff area, while others have operational warehouses located in the vicinity (Hjerpe and Kim 2003). In addition, noncommercial boating parties rent equipment and purchase food from local vendors and outfitting companies. Flagstaff is also the place of residence for many of the commercial guides.

Hualapai Indian Reservation and Peach Springs

The Hualapai Indian Reservation is on the south side of the Colorado River to the west of the main portion of Grand Canyon National Park. The population of the Hualapai Tribe was 1,542 in 2000 (U. S. Bureau of the Census 2000). Tribal, public school, and state and federal governmental services provide the bulk of current full-time employment. The tribe's principal economic activities include tourism, cattle ranching, timber sales, and arts and crafts. Peach Springs, the tribal capital, is a rural community of 600 people located on the Diamond Creek road and historic U. S. Route 66. The Diamond Creek road is the first road access to the Colorado River below Lees Ferry, making it important for river trips both leaving and entering the Grand Canyon.

The median income on the Hualapai Reservation is less than half the comparable figure for Coconino County, its poverty level is approximately double, and its unemployment rate is approximately 60% higher than for Coconino County. Peach Springs, the reservation's single town, fares only slightly better than the reservation as a whole in a similar statistical comparison (Table 3-18).

Economic activities tied to the Grand Canyon and the Colorado River are vital to the economy of the Hualapai Tribe and its members. Based on economic data from the Hualapai Tribe, Lower Gorge activities (pontoon trips, HRR trips, and helicopter land-and-leave tours from Grand Canyon West) accounted for more than 90% of the tribe's river-related revenue in 2003, while Upper Gorge activities (Whitmore helicopter exchange fees and lease fees and Diamond Creek access fees) accounted for less than 10%.

The landing at Diamond Creek is a prime takeout for river rafters. Approximately 85% of noncommercial river rafting trips and a large percentage of commercial trips end at Diamond Creek (Hjerpe and Kim 2003). Diamond Creek is also the starting point for Hualapai Tribe-guided trips through the lower Grand Canyon and a few noncommercial trips. The Hualapai Tribe maintains Diamond Creek road, a rough, graded gravel road subject to periodic flash

TABLE 3-18: DEMOGRAPHIC DATA ON THE TOWN OF PEACH SPRINGS, THE HUALAPAI RESERVATION, THE HAVASUPAI RESERVATION, AND COCONINO COUNTY

	Population	Median Household Income	Unem-ployment Rate	Percentage of Families/ Individuals below Poverty Level	Employment			
					Occupation	%	Industry	%
Peach Springs	600	$18,194	7.7%	38.2% / 36.6%	Management/ professional	22.5%	Public administra-tion	18.5%
					Service	28.7%	Education, health, social service	32.0%
					Sales/office	23.6%	Recreation, arts, entertainment	17.4%
Hualapai Reservation and Off-Reservation Trust Land	1,353	$19,833	8.2%	35.8% / 35.8%	Management/ professional	25.0%	Public administra-tion	26.9%
					Service	25.0%	Education, health, social service	26.3%
					Sales/office	26.9%	Recreation, arts, entertainment	16.6%
Havasupai Reservation	503	$20,114	5.2%	46.1% / 50.2%	Management/ professional	13.6%	Public administra-tion	23.5%
					Service	33.3%	Education, health, social service	8.6%
					Sales/office	27.2%	Recreation, arts, entertainment	17.3%
Coconino County	116,320	$38,256	4.8%	13.1% / 18.1%	Management/ professional	34.8%	Public administra-tion	6.8%
					Service	19.1%	Education, health, social service	26.9%

flooding, and charges a fee of $37.45 per person for tourists and river runners exiting or entering the Colorado River. HRR river rafting is the only tribally owned and operated river rafting company on the Colorado River. The Hualapai Tribe, through its Grand Canyon Resort Corporation, is also responsible for managing the tribe's Hualapai Lodge near Peach Springs. HRR offers one- and two-day motorized river rafting trips through the Lower Gorge from Diamond Creek to Lake Mead. Although these trips are conducted within the park, user-days are not counted by the park below Diamond Creek. During the 2003 season, the price for the one-day trip was $265 per person and included a helicopter ride from Quartermaster to Grand Canyon West. HRR is not licensed or regulated by the National Park Service. Farther down the river, at RM 262, helicopters operating for the Hualapai Tribe carry people to the river for a quick pontoon boat ride and then a helicopter trip out at the same point. The tribe currently earns $48.50 per passenger (including helicopter pad leasing fees) from the tour operator that runs the trips under a concession arrangement with the tribe.

The Hualapai Tribe receives revenue from helicopter landing pads both above and below Diamond Creek. The pad near Whitmore (RM 187) is used to take in and bring out passengers from commercial river trips. The tribe receives $15 per person for each exchange by helicopter at Whitmore. The helicopter pads at RM 261 are used for day trips that do not involve on-river activities. Helicopter pads at RM 262 and RM 263 are leased to helicopter companies serving HRR river trips, pontoon trips, and trips not involving on-river activities. Noncommercial river rafting passengers do not exchange at these pads.

Havasupai Indian Reservation and Supai Village

The Havasupai Indian Reservation and the community of Supai are located off the South Rim of the Grand Canyon in Havasupai Canyon. The Colorado River is approximately 10 miles and 1,300 feet below Supai Village. Approximately 500 residents live in Supai. The median household income on the Havasupai Reservation is approximately 53% of the comparable Coconino County figure, and the percentage of families with incomes below poverty level is over 350% of the Coconino County figure. One-third of the occupations on the Havasupai Reservation are in the service sector, and public administration is the largest industry (Table 3-18).

Tourism is the main economic basis for the tribe. However, there is no road access to Supai, so tourists visit by hiking an 8-mile trail, by riding horseback or mule, or taking a helicopter. Supai has campgrounds, a lodge, a general store, a cafe, and a post office. Horses are also available for rent. Visitors are charged an entry fee of $20 and a camping fee of $10 per night. No data are available on how much is collected on a yearly basis. The tribe has indicated that the number of river runners who access the reservation without paying the appropriate fees is a major issue.

Marble Canyon, Arizona

Marble Canyon, including Cliff Dwellers and Vermillion Cliffs, is a rural community of approximately 500 people near the Lees Ferry crossing of the Colorado River. Prior to the construction of Glen Canyon Dam, Lees Ferry was the only Colorado River crossing for many miles. The construction of the dam has created a thriving rainbow trout fishery, which has become a major tourist draw and contributor to the local economy. Two of the Grand Canyon river-running concessioners base their operations out of the Marble Canyon area. Lees Ferry is the starting point for virtually all Grand Canyon boating trips. Many boaters purchase fuel, food, refreshments, and equipment in Marble Canyon. The major economic activity for the town is providing guide services to the rainbow trout fishery.

Kanab, Utah

Kanab, Utah, is a city of about 3,600 people just north of the Arizona/Utah border and is the county seat for Kane County. Tourism is the leading industry for Kanab due to its close proximity to Bryce Canyon, Grand Canyon, and Zion national parks. Grand Canyon tourists journeying to and from the remote North Rim heavily influence Kanab. Kanab is home to 1 of the 16 river concessioners and is a recognized stopping point for river runners approaching Lees Ferry from the north.

Fredonia, Arizona

Fredonia, Arizona, is a sister community to Kanab and is immediately across the state line. In 2000 Fredonia had a population of 1,036; its economy is based primarily on tourism and agriculture (U. S. Bureau of the Census 2000). Two outfitters maintain warehouses in Fredonia.

Seligman, Arizona

Seligman, Arizona, is in Yavapai County on I-40 and Route 66. Tourists, hunters, and recreationists purchasing food, supplies, and services provide the main sources of income to this town of approximately 500 people. Its proximity to the Grand Canyon, Havasupai Canyon, and Grand Canyon Caverns, as well as its location on Route 66, attracts tourists. Grand Canyon boaters exiting at Diamond Creek and returning to Flagstaff typically stop in Seligman for food. The percentage of Seligman's income specifically attributable to Grand Canyon river runners is not known.

Bar 10 Ranch

The Bar 10 Ranch is a privately owned working cattle ranch and tourist destination about 9 miles from the North Rim up the side canyon of Whitmore Wash, just west of the Mt. Logan Wilderness Area. The ranch can be accessed by a rugged and primitive dirt road from St. George, Utah, but most visitors fly in and out by way of a local airstrip. The ranch offers food and lodging, helicopter tours, ATV tours, horseback riding, pack trips, and entertainment. However, the majority of visitors are river runners finishing or beginning a Grand Canyon river rafting trip. The ranch has partnered with many of the river concessioners to offer package trips that include helicopter transportation to and from the Whitmore helipad, including an afternoon visit and meal at the ranch.

Approximately 80% of the ranch's 10,000 annual guests are Grand Canyon river runners visiting mainly from May through September. Approximately 30% of river runners stay overnight. According to the owners, the charge for day-use rafters is approximately $75, while overnight rafting guests pay approximately $165 for additional lodging, entertainment, and meals. An estimated $25 of the charge is paid to the helicopter shuttle operator (Papillon Airways, Inc.) for the helicopter shuttle trip to or from Whitmore.

Helicopters currently carry river-runners from the Whitmore exchange to the ranch. Without helicopter access, the route from the river to the ranch requires a 1.3-mile hike on an unmaintained trail, followed by a 9-mile drive on a primitively maintained dirt road. Prior to 1985, the ranch utilized mules to bring customers up the trail.

Meadview, Arizona

According to the Chamber of Commerce, Meadview is largely a retirement community; of its 2,000 residents, approximately 70 are employed either full- or part-time. Places of employment include three restaurants, three motels, two RV parks, a grocery store, and a post office. A tile designer employs about 25 to 28 people. Tourism is generally from RV or other road-based visitors who stay in the RV parks or motels. The contribution by river rafters to the local economy is very small (Newell 2004). River rafters frequent local restaurants and grocery stores and gas stations during the main season. Noncommercial rafters also use the local vehicle shuttle service company to shuttle cars between Lees Ferry, Diamond Creek, and South Cove throughout the year.

Page, Arizona

Page is a planned community near the Arizona/Utah border, near Glen Canyon Dam. The principal contributors to its economy are tourism, Lake Powell, the Navajo Generating Station, and the federal government (Arizona Department of Commerce 2003). Recreational properties and public utilities provide substantial employment to the city's population of 6,809 (U. S. Bureau of the Census 2000). According to the Arizona Department of Commerce and NPS estimates, the Page/Lake Powell area hosted 3.1 million visitors in 1997.

Navajo Nation and the Communities of Cameron and Bodaway / Gap

The Navajo Nation Reservation and off-reservation trust lands are located in Arizona, New Mexico, and Utah, with a combined population of 180,462 people (U. S. Bureau of the Census 2000). Navajo Nation lands border Grand Canyon National Park to the east and are adjacent to the Colorado River between RM 0 and RM 61 (the confluence of the Colorado and Little Colorado Rivers). Hiking trails leading into Grand Canyon National Park, such as Jackass Canyon, Salt Trail Canyon, and Totahatso Point, are on Navajo land and require backcountry use permits and $5 per night camping fees. These permits are available through Navajo Nation Parks and Recreation, Window Rock, Arizona. As the Navajo Nation collects fees for access and spends resources on environmental protection and search-and-rescue operations, trespass on Navajo Nation lands by river runners creates the possibility of an economic impact.

The Navajo communities nearest the Grand Canyon are Bodaway / Gap and Cameron. These communities are on U. S. Highway 89, the main road between Flagstaff and Lees Ferry. Gas, food, and lodging are available in Cameron, while Bodaway / Gap offer Indian crafts and souvenirs to passing tourists. These communities are small and remote, and neither the U. S. Bureau of the Census nor the Arizona Department of Commerce provides detailed statistics on them. In estimating the regional economic impacts of Grand Canyon river runners, Hjerpe and Kim (2003) found that commercial rafters spent approximately $5,000 in Cameron in 2001 for souvenirs and food, while noncommercial boaters spent perhaps $200 in Cameron annually.

RIVER-RUNNER GENERATED ECONOMY

In 2003 commercial rafters alone paid more than $28 million to commercial outfitters for guided trips. In addition, both commercial and noncommercial rafters purchased equipment, supplies, and services. However, a major proportion of this spending is paid to businesses outside the Grand Canyon region; consequently, this spending has no economic benefit to the regional economy. Hjerpe and Kim (2003) estimated that 87% of the commercial rafters expenditures and 74% of noncommercial rafters spending remained in the region. The direct regional expenditure of $26.6 million and creation of 461 jobs resulted in the indirect and induced effects of $34.6 million in regional output and the creation of an estimated 582 jobs. This represents approximately 0.7% of the region's total economic output.

COMMERCIAL RIVER RUNNERS

Concession operators are permitted to run commercial river rafting trips down the Colorado River under concession contracts with the National Park Service. These contracts set parameters by which river rafting trip prices are controlled.

Commercial boaters paid almost $250 per day on average for their trips in 2003. On average, motorized trips are more expensive than non-motorized trips ($255 vs. $241 per day), but that is mainly because motor trips tend to be shorter (7.3 days vs. 13.6 days on average), and commercial outfitters charge more per day on shorter trips. For trips of the same length, those using motors typically charge a lower price per day than those using oars. Grand Canyon river rafting trip prices are comparable to those charged for rafting other rivers within the United States. Prices per day vary substantially depending on the outfitter and the trip configuration chosen.

The primary economic sectors affected by commercial river-runners are food service; lodging, amusement and recreation services; recreational equipment; and passenger transportation. Most of the spending in the amusement and recreation services sector is in the form of wage and benefits payments to commercial trip guides and staff. The passenger transportation sector for commercial runner expenditures includes shuttle transportation to and from the canyon (including helicopter transport), but not individual transportation to the region. Based on Hjerpe and Kim (2003), it is estimated that commercial passengers generate $214 per person per day for the Grand Canyon region's economy from their river rafting trip purchases and other trip-related spending. This Grand Canyon regional spending consists of that portion of commercial river rafter's goods or services purchases (such as outfitter trips) that occurs within the Grand Canyon region's economy. Commercial river rafters' spending outside the Grand Canyon region are not counted in this analysis.

NONCOMMERCIAL RIVER RUNNERS

Noncommercial river rafters spend significantly less per day than commercial rafters to run the Colorado River because they do not purchase the services of commercial operators to do so. Hjerpe and Kim (2003) estimate that noncommercial boaters spend an average of $47 per person per day in the region.

Noncommercial boaters spend money on river rafting equipment, food, fuel, transportation, park fees, and tribal land access fees. The largest portion of noncommercial boaters' regional expenditures is on food and beverage supplies for their river trips (33%) followed closely by equipment rentals and purchases (25%). About 15% of noncommercial boaters' regional spending goes to pay park fees. The transportation sector for noncommercial boaters expenditures includes shuttles to and from the canyon (8%), as well as individual air transportation to northern Arizona. Hotels also benefit from business with noncommercial boaters. Increasingly, noncommercial boaters are choosing to use the services of local outfitting companies to provide noncommercial trips with the necessary equipment and supplies for their entire trip.

It appears that noncommercial rafters spend less than commercial rafters for several reasons. They do not purchase commercial guide services, and they may bring most of their equipment and supplies from outside the region. Noncommercial rafters typically spend longer on the river

than commercial rafters and, as a result, their average daily spending for "off-river" expenses are spread out over a longer trip length. Additionally, the data for this analysis were obtained from two different sources of information — commercial operators' reported data, and survey information obtained from individual river runners.

COMMERCIAL OPERATORS

There are 16 licensed outfitters offering river trips on the Colorado River through Grand Canyon National Park. The National Park Service issues concession contracts (formerly operating permits), which are scheduled for resolicitation in 2005. It is expected that the 16 current concessioners will be regarded as guides and outfitters within the meaning of 36 CFR 51.38 and that they therefore will have the right of preference over other bidders for any new concession contracts for river running.

The number of user-days allocated to each concessioner varies widely. The largest commercial operators are allocated approximately 14,000 user-days per year, while the smallest operators have less than 3,000 user-days. The six largest operators manage approximately 70,000 user-days, or more than 60% of the total user-day allotment for commercial operators. Of the 16 Grand Canyon river concessioners, 10 conduct supplemental operations not involving Grand Canyon river rafting. Most of these additional operations involve guided raft trips on other sections of the Colorado River and other rivers throughout the west, such as the San Juan and Green rivers. Other operations conducted by Grand Canyon river concessioners include lodging and camping concessions in Kaibab National Forest, lodging and food facilities in other national parks, and horseback and Jeep tours. In addition to the commercial operators operating above Diamond Creek, HRR also runs commercial trips downriver from Diamond Creek.

A wide variety of trip configurations are offered by the Grand Canyon river concessioners. Many of the commercial operators have the operational and scheduling flexibility to adjust and tailor their trip lengths, destination, passenger exchanges, and equipment to meet their customers' preferences. Table 3-19 presents the most popular trip configurations offered from 1998 to 2001.

Passenger exchanges at Phantom Ranch and Whitmore currently offer important operational and financial opportunities for the commercial operators. The exchanges enable operators to offer shorter trips and provide more scheduling opportunities for users who have limited time for running the river. The convenience and time savings associated with helicopter exchanges increase the customer base for river trips. In addition, the helicopter rides in and out of the canyon offer another income source for the companies. On their arrival or departure day at an exchange, user-days are only counted as the larger number of those going in, or coming out, thus there is no double counting of the commercial operator's user-day allocation. However, most commercial passengers pay a full day for these exchange days. As a result, the concessioner can earn two days of revenues for the one user-day spent by the two passengers leaving or joining a trip. This incentive favors short trips.

TABLE 3-19: MOST POPULAR COMMERCIAL OPERATORS TRIP CONFIGURATIONS FROM 1998 TO 2001

	Most Popular Trip Configurations			
Commercial Operators	**Boat Type**	**Trip Length**	**Trip End**	**% of Trips**
Arizona Raft Adventures	Hybrid*	13 day	Diamond	37%
	Motor	8 day	Diamond	30%
Arizona River Runners	Motor	6 day	Whitmore	51%
	Motor	7 day	Lake	32%
Canyon Expeditions	Hybrid	15 day	Diamond	30%
	Hybrid	12 day	Diamond	23%
	Hybrid	14day	Diamond	17%
Canyon Explorations	Hybrid	15 day	Diamond	51%
	Hybrid	16 day	Diamond	24%
Canyoneers	Motor	7 day	Lake	99%
Colorado River and Trail Expeditions	Motor	8 day	Lake	47%
	Motor	9 day	Lake	19%
Diamond River Adventures	Motor	8 day	Diamond	42%
	Motor	7 day	Whitmore	36%
Grand Canyon Expeditions Company	Motor	8 day	Lake	94%
Hatch River Expeditions	Motor	7 day	Whitmore	72%
High Desert Adventures**	Motor	8 day	Lake	59%
	Oar	12 day	Whitmore	22%
Moki Mac River Expeditions	Oar	14 day	Lake	44%
	Motor	8 day	Lake	40%
O.A.R.S	Dory	16 day	Lake	19%
	Oar	15 day	Lake	17%
	Oar	13 day	Diamond	15%
Outdoors Unlimited	Hybrid	12 day	Lake	42%
	Hybrid	13 day	Lake	27%
Tour West	Motor	6 day	Lake	45%
	Motor	6 day	Whitmore	16%
	Oar	12 day	Whitmore	14%
Western River Expeditions	Motor	6 day	Lake	99%
Wilderness River Adventures	Motor	8 day	Whitmore	52%
	Motor	7 day	Whitmore	28%

Source: Grand Canyon River Outfitters Association (2003).

* Hybrid = oar trip with motor support.

** Outfitter no longer exists; was purchased by Arizona Raft Adventures.

REVENUES AND EXPENSES

In 2003 commercial operators had total annual revenues of approximately $28.8 million and generated approximately $250 per user-day. The operators' profits vary. Typically smaller operators (i.e., those allocated fewer user-days) have higher operating costs because their fixed costs cannot be spread over as much revenue. On average, direct labor costs are estimated to represent 15.4% of commercial operators' revenues, and they are typically higher for non-motorized trips (18.4%) than for motorized ones (13.7%) because of the higher guide-to-client ratio on non-motorized trips.

River rafting operators' costs can be separated into four categories: (1) direct operating expenses, (2) indirect operating expenses, (3) fixed expenses, and (4) franchise fees. Direct operating expenses represent varying costs associated with providing services to customers, such as guide salaries, food, and other supplies. Indirect expenses consist of officer salaries and in some cases, management fees. In general, fixed expenses consist of business costs such as rent, insurance, taxes, and depreciation costs, which do not vary significantly as the level of service changes.

Franchise fees are a percentage of gross revenue, paid directly to the National Park Service by the concessioners.

For the typical river rafting operator, fixed expenses are a relatively minor component of their total costs. While commercial river rafting does require equipment expenditures (rafts, motors, tents, and kitchen and other camping equipment), it is a labor-intensive business where a considerable proportion of the value to customers is associated with managerial and staff expertise and experience. Many direct operating costs are variable and can be readily adjusted to different operating conditions, trip configurations, or service requirements.

The National Park Service collects franchise and Colorado River Fund fees from commercial operators to make improvements along the Colorado River. According to Grand Canyon National Park, in 2003 the total franchise and Colorado River Fund fees paid by Grand Canyon river rafting concessioners were $2.6 million. This represents an 8.9% franchise fee on revenues.

Capital expenses of commercial river-rafting companies are relatively low compared with many other concession operations or service industries. Furthermore, the useful life of most of the operators' capital items are short (e.g., five to seven years for rafts and motors), and most operators have been able to depreciate a majority of their investment over the length of their ongoing concession agreements. Any necessary phasing out of existing equipment and purchases of new equipment could be readily amortized over the length of these concession agreements.

PARK MANAGEMENT AND OPERATIONS

LEES FERRY TO DIAMOND CREEK (ZONE 1)

Recreational and administrative use of the Colorado River in Grand Canyon National Park is managed in accordance with the 1989 *Colorado River Management Plan,* the1995 *General Management Plan,* and applicable NPS laws, policies, and regulations. Table 3-20 summarizes the park's river management programs and operations.

TABLE 3-20: CURRENT RIVER MANAGEMENT ACTIVITIES AND RESPONSIBLE PARK DIVISIONS

Park Division	River Management Responsibilities	Staff/FTE*
Visitor and Resource Protection	Ranger activities: river patrols, concession evaluations and visitor education, search and rescue, Lees Ferry and Meadview operations; river permits	10.0
Science Center	Research, resource management, inventory and monitoring, planning and compliance, rehabilitation/restoration, research permits	4.0
Concessions	Commercial activities	1.0
Interpretation	Education and interpretation	0.5
Maintenance	Trail and facility maintenance	1.0

* This column indicates the staff time associated with river management activities. These are measured in FTE or full-time equivalents (100% time allocated). With the exception of river rangers and some permit staff, very few staff are 100% allocated to river management activities. The FTEs at the Science Center do not include planning and compliance.

RIVER PERMITS PROGRAM

The Backcountry Information Center manages the permit programs for noncommercial river users, backcountry visitors, and other short-term special uses (e.g., special events, public assembly, first amendment activities, and weddings).

The river permits operation includes maintaining the noncommercial waitlist (over 8,000 names), issuing and tracking noncommercial river permits, handling cancellations, and answering public information phone lines. The River Permits Office oversees and evaluates waiver requests through the "On-line Launch Calendar" used by the park and commercial operators to schedule, track, and report actual commercial river use. Tens of thousands of telephone calls, e-mails, and letters related to the river program are received and/or sent out by this operation each year.

RANGER ACTIVITIES

The River Patrol rangers are responsible for operations that include visitor education, law enforcement, concession operation evaluations, and support for maintenance, education, and resource management activities. Park rangers conduct patrols primarily during the high use period. Search-and-rescue operations are managed by the NPS Emergency Services Branch, and river patrol rangers typically support these operations from the river. All NPS river trips are coordinated through an operations and equipment manager. The NPS fleet consists of 12 fully equipped oar-powered rafts, two 22-foot motorized rafts, and two rigid hull inflatable jet drive boats for Lake Mead and Lees Ferry rangers.

Under a partnership with Glen Canyon National Recreation Area, Grand Canyon river rangers manage Colorado River trip activities. The primary function of the Lees Ferry rangers is to ensure that commercial outfitters and noncommercial boaters comply with environmental and safety regulations. Specifically, park rangers conduct an orientation for noncommercial boaters that includes equipment check and an educational program. Rangers periodically inspect commercial trips to ensure compliance with safety and environmental regulations. Lees Ferry rangers administer the Grand Canyon guides licensing program, and they have responsibility for search-and-rescue programs and law enforcement in the upper Marble Canyon area.

RESEARCH, RESOURCE MANAGEMENT, MONITORING, PLANNING, COMPLIANCE, REHABILITATION / RESTORATION

The Grand Canyon Science Center conducts, coordinates, and/or contracts for resource management and research activities for Grand Canyon National Park, often in close cooperation with other park divisions, cooperators, and tribes. The Science Center is comprised of resource management specialists (cultural, wildlife, vegetation, water, earth resources, and social sciences), planners, NEPA compliance specialists, and research program managers. The Science Center has primary responsibility for inventory, monitoring, and mitigation for cultural resources, wildlife, threatened/endangered species, campsites, other park resources, and visitor experiences. In cooperation with park rangers, trail crew, and other park staff, Science Center staff design and implement projects to address resource concerns and impacts, including visitor impacts on vegetation, archeological sites, wildlife habitat, water quality, and campsite condition.

All research conducted along the Colorado River within Grand Canyon National Park is reviewed and authorized through the Science Center. This includes the extensive and long-term research and monitoring undertaken through the Glen Canyon Dam Adaptive Management Program (primarily through the USGS Grand Canyon Monitoring and Research Center). Research must meet park goals and objectives, and it is reviewed to ensure consistency with wilderness management objectives.

The Science Center also provides compliance and planning services. Routine and non-routine management activities require written documentation for environmental compliance (e.g., National Environmental Policy Act, National Historic Preservation Act, and Endangered Species Act) and for the minimum tool requirements as required by NPS wilderness management policy.

COMMERCIAL ACTIVITIES

The Concessions Division manages the park's concessions contracts for commercial river trips operating in the park. To do this, the division develops contracts, administers fees, oversees operations, and sets rates for services provided under the contracts. The Concessions Division also issues incidental business permits for river trip support services (e.g., equipment rental and shuttles), although the level of oversight for this type of permit is much lower than that for contracts.

TRAIL AND FACILITY MAINTENANCE

The park's trail crew in the Maintenance Division maintains all designated trails and routes, including those accessible from the river to popular destination sites and rapid scouting areas. The trail crew conducts routine maintenance and rehabilitation of trails and routes, and they assist in some types of rehabilitation/restoration projects. In addition, they are responsible for maintaining primitive toilets in the backcountry.

INTERPRETATION AND RESOURCE EDUCATION

The Division of Interpretation and Resource Education cooperates with other park divisions, universities, nonprofit organizations, and other educational groups to provide educational opportunities on the river, to develop curricula and written interpretive materials, and to conduct service projects tied to park Science Center projects along the river corridor.

Additionally, the division provides staff to assist other park divisions in conducting their activities on the river. Interpretive staff members also provide interpretive training for licensed guides, outfitters, and other groups.

PARTNERSHIPS AND COOPERATIVE MANAGEMENT PROGRAMS

Table 3-21 summarizes NPS river trips from 2000 to 2003. NPS resource management, research and educational trips have been supported through partnerships, cooperative agreements, and grant-funded programs. The Cooperative Resource Conservation Program, for example, included 14 outfitter-sponsored trips in support of inventory and monitoring, trail and campsite maintenance, archeological site mitigation, and exotic plant management. Educational trips have also been conducted under partnerships or agreements with universities, colleges, and other agencies.

TABLE 3-21: SUMMARY OF ADMINISTRATIVE USE, 2000–2003

Purpose	Total Trips	Motorized Trips	Non-motorized Trips	Sponsor
Patrol	14	3	9	NPS
Trails	6	0	6	NPS
Cooperative Resource Program*	12	2	10	NPS/Outfitters
Educational	3	0	3	GC Youth
Educational	1	0	1	Project Watershed
Education / Monitoring	3	0	3	NAU/NPS
Guide Training	4	Mixed/Both	Mixed/Both	Guides/NPS
Education / Research	1	0	1	Prescott College/NPS
Research	17	0	17	NPS**
Research	164	105	59	GCMRC

** NPS research: Most resource specialist hold research permits for natural and cultural resource data collection and mitigation.

LOWER GORGE (ZONES 2, 3 AND 4)

Similar to the Lees Ferry to Diamond Creek section of the Colorado River, park river management programs in the Lower Gorge are directed by resource management plans and applicable regulations and policies. Compared to management in Zone 1, park management presence is reduced and Hualapai Tribal management activities are increased.

RIVER PERMITS PROGRAM

Permits for river trips launching from Diamond Creek are issued by Grand Canyon National Park and the Hualapai Tribe. The park's River Permits Office sends a copy of the approved permit application to the Hualapai Tribe, which in turn issues a permit and collects the appropriate access fees.

RANGER ACTIVITIES

The Grand Canyon river patrols typically take-out at Diamond Creek, although at least one patrol per year (2000–2003) has continued to Lake Mead. River patrols in Zones 2, 3, and 4 are the primary responsibility of the park's Meadview ranger. Meadview is adjacent to Lake Mead National Recreation Area, near the upper end of Lake Mead. Grand Canyon National Park ranger patrols launch from the South Cove landing and travel upriver to Separation Canyon. They perform permit and safety inspections, and also provide information, search-and-rescue, law enforcement, and various resource management activities. In cooperation with Lake Mead, the Grand Canyon rangers manage takeout activities at South Cove (and Pearce Ferry when lake levels are high).

RESEARCH, RESOURCE MANAGEMENT, MONITORING, PLANNING, COMPLIANCE, REHABILITATION / RESTORATION

In cooperation with the Hualapai Tribe, the Grand Canyon Science Center conducts resource management activities and coordinates research in the Area of Cooperation (RM 164.5 to RM 273). Similar to Zone 1, the Science Center conducts inventory, monitoring, and mitigation for cultural resources, wildlife, threatened/endangered species, campsites, other park resources, and visitor experiences. However, these activities are infrequent compared to resource management trips in Zone 1. The Meadview ranger conducts campsite monitoring and maintenance (trash collection, fire pit clean-up, etc.).

Research conducted along the Colorado River in the Lower Gorge is reviewed and authorized through the Science Center in coordination with the Hualapai Tribe. This includes extensive and long-term research and monitoring undertaken through the Glen Canyon Dam Adaptive Management Program (primarily through the USGS Grand Canyon Monitoring and Research Center). Research must meet park goals and objectives and Hualapai tribal regulations.

COMMERCIAL ACTIVITIES

HRR trips are managed through the Hualapai Tribal Enterprises. The Grand Canyon National Park's Concessions Division has no authority to manage HRR trips. Under the Memorandum of Understanding between the Hualapai Tribe and the National Park Service, HRR trips are subject to operational standards required of all NPS river concessioners.

TRAIL AND FACILITY MAINTENANCE

The park's trail crew does not currently conduct trail or facility maintenance in Zone 2, 3 or 4. The Diamond Creek road and facilities at Diamond Creek, Spencer Canyon, and the Quartermaster Area are maintained by the Hualapai Tribe.

INTERPRETATION AND RESOURCE EDUCATION

Some of the activities developed through the park's Division of Interpretation and Resource Education are applicable in the Lower Gorge zones. Educational specialists are involved in cooperative youth trips. NPS and Hualapai Tribe educational materials are available from the Meadview ranger station.

ADJACENT LANDS AND JURISDICTIONS

As noted in the 1979 *Colorado River Management Plan and Final Environmental Impact Statement,* the river corridor and its recreational use are influenced to varying degrees by agencies that administer or manage lands and resources adjacent to Grand Canyon National Park. River running, in turn, has the potential to affect management of these lands and resources.

U.S. BUREAU OF RECLAMATION

The Bureau of Reclamation (BOR) has responsibility for the management of Glen Canyon and Hoover Dams, including water storage and releases. Monthly releases are identified in an annual operating plan. Daily and hourly releases within those monthly constraints are determined by the Western Area Power Administration in response to power demand. Current dam and reservoir operations and their effects on river running in the Grand Canyon are summarized in at the beginning of this chapter. Coordination between the National Park Service and the Bureau of Reclamation is necessary to keep river runners informed about water release schedules from Glen Canyon Dam and the level of Lake Mead.

As part of the Secretary of the Interior's responsibilities for management of both the water resources held behind Glen Canyon Dam and the provisions of the Grand Canyon Protection Act of 1992 (Public Law 102-575), the Bureau of Reclamation, along with 26 other stakeholders, work cooperatively on the Glen Canyon Dam Adaptive Management Program. This federal, multi-stakeholder program was initiated in 1996 to comply with provisions of the Grand Canyon Protection Act and the *Operation of Glen Canyon Dam Final Environmental Impact Statement* (BOR 1995). Its purpose is to provide an organization and process for cooperatively integrating dam operations, downstream resource protection and management, and monitoring and research information.

UNITED STATES GEOLOGICAL SURVEY

Research and monitoring of the operations of Glen Canyon Dam are undertaken through a branch of the United States Geological Survey entitled the Grand Canyon Monitoring and Research Center, which was created to fulfill legal obligations of the Secretary of the Interior after the signing of the "Record of Decision" for Glen Canyon Dam operations. The center oversees flow experiments and monitors the impact of dam operations on downstream resources, including water quality, sediment transport and deposition, fish and other aquatic resources, the riparian ecosystem, cultural sites, and recreational activities. River recreation-related efforts have focused on changes in the area; the number, location, and quality of campsite beaches; recreational safety; methods for and enhancement of the wilderness experience; changing user preferences; and angler satisfaction. The center sponsors research and monitoring activities on the river, which require research permits from Grand Canyon National Park; the park requires a minimum requirement analysis on proposed operations.

OTHER NPS ENTITIES

GLEN CANYON NATIONAL RECREATION AREA

Most Grand Canyon river trips launch at Lees Ferry within Glen Canyon National Recreation Area. Glen Canyon encompasses 1,254,306 acres upstream of the Grand Canyon, most of which encompasses Lake Powell above Glen Canyon Dam, but also includes approximately 15 miles of the Colorado River below the dam. Attractions in this 15-mile river reach include a rainbow trout fishery, historic ranch and ferry properties at Lees Ferry, hiking trails, and spectacular scenery. Private boating is popular, and daily, concession-operated, flat-water raft trips are available from the dam to the Lees Ferry dock. In FY 2002, 34,849 passengers participated in these half-day motorized trips. Several professional fishing guides operate out of Lees Ferry. The concessioner-operated flat water trips and commercial fishing guides are overseen by Glen Canyon National Recreation Area.

Management guidance for Glen Canyon is provided by the 1979 *Glen Canyon National Recreation Area General Management Plan* and the *Strategic Plan for Glen Canyon National Recreation Area and Rainbow Bridge National Monument, October 1, 2000–September 30, 2005* (NPS 2000e). The recreation area is also preparing a Colorado River recreation report that will provide information to help determine the types and amounts of use that are appropriate on the river. Glen Canyon staff manage most of the Lees Ferry area, but activities associated with downstream river running are the responsibility of Grand Canyon National Park. Standard operating procedures and a memorandum of understanding govern coordination between the two park units.

Glen Canyon maintains a launch ramp, dock, campground, ranger station, patrol boats, and supporting infrastructure at Lees Ferry. Grand Canyon maintains a patrol boat, as well as an orientation trailer and information kiosk near the ramp. Permanently assigned Grand Canyon rangers provide information, give formal orientation talks to noncommercial parties, check noncommercial permits, inspect rigs to ensure compliance with NPS regulations, assist Glen Canyon personnel with upriver use, and administer the guide-licensing program.

Approximately 900 downriver trips are launched annually from Lees Ferry, with the majority leaving May-September. Five or six trips launch on a typical summer day, and the ramp area is filled with boats, commercial passengers and guides, noncommercial river runners, and logistical personnel who drive shuttle cars, buses, or trucks and help assemble and launch boats. Upriver boaters use a separate, paved ramp and the dock. The area can become congested during the summer months.

LAKE MEAD NATIONAL RECREATION AREA

Lake Mead National Recreation Area encompasses 1,495,664 acres, mostly downstream of Grand Canyon National Park. Former Lake Mead lands north of Grand Canyon have been incorporated into Grand Canyon–Parashant National Monument. River runners cross the boundary into Lake Mead at RM 277. At capacity Lake Mead waters back up over 40 miles into the Grand Canyon, and boat traffic from the lake is allowed to proceed upstream as far as

Separation Canyon (RM 240). Many river trips originating at Lees Ferry and all trips originating at Diamond Creek terminate in Lake Mead. Until 2001 most of these trips took out at Pearce Ferry (RM 280), but now that this ramp is inaccessible due to low lake levels, trips must travel an additional 18 miles to South Cove. Use of boat ramps and facilities in Lake Mead by river runners, and upriver travel into Grand Canyon from Lake Mead, require close coordination between both park units. In an arrangement similar to the one at Lees Ferry, Lake Mead and Grand Canyon have standard operating procedures and a memorandum of understanding in place to facilitate coordination. A ranger from Grand Canyon's River District resides at Meadview, Arizona, and assumes responsibility for the 52 miles of river from Diamond Creek to the Lake Mead boundary. The emphasis of patrols in this area is monitoring commercial and private river runner activity. The Grand Canyon ranger also assists Lake Mead personnel with boat ramp management at Pearce Ferry and South Cove. Lake Mead personnel participate with Grand Canyon and Hualapai Tribe representatives in Core Team meetings to facilitate management of the lower Grand Canyon and upper Lake Mead area.

Guidance for managing Lake Mead is provided by the 1986 *Lake Mead National Recreation Area General Management Plan* (NPS 1986b) and the 2002 *Lake Management Plan* (NPS 2002b). According to the *Lake Management Plan,* the Colorado River delta area of Lake Mead (from Paiute Point to the Grand Canyon boundary) is to be managed as a rural natural area as long as Grand Canyon continues to allow motorized river craft from Lake Mead to enter the park. Personal watercraft use, waterskiing, and wakeboarding are permitted in rural natural areas of Lake Mead. If Grand Canyon disallows upriver motorized travel from Lake Mead, the delta area will be considered semi-primitive, and personal watercraft use, waterskiing, and wakeboarding will not be permitted. Regardless of regulations governing Lake Mead, these activities are not permitted within Grand Canyon. Lake Mead's *Lake Management Plan* also calls for the prohibition of two-stroke carbureted engines within the recreation area after 2012. This will reduce noise and air pollution resulting from upriver boat traffic in the Grand Canyon. Current planning at Lake Mead includes a proposed amendment to the *General Management Plan* to evaluate the public launch ramps and marinas on Lake Mead in relation to the effects of the dropping reservoir levels. Grand Canyon is cooperating with Lake Mead in addressing related problems at the launch ramps used by river runners.

BUREAU OF LAND MANAGEMENT

The Bureau of Land Management (BLM) Arizona Strip Field Office manages, or in the case of Grand Canyon-Parashant National Monument, co-manages, approximately 2.8 million acres of land north and west of the Colorado River in Arizona. Included in this vast region are two national monuments and eight wilderness areas. BLM-administered land currently affected by river running in the Grand Canyon is limited to Grand Canyon-Parashant National Monument, which borders the western portion of the park between the Grand Wash Cliffs and the Toroweap Valley area. The primary issue is the use of BLM roads to access facilities and trails used by Grand Canyon river passengers exchanging in the Whitmore area.

Currently, the Bureau of Land Management and National Park Service through Lake Mead National Recreation Area are cooperating in a planning process that includes a revision of the 1992 *Arizona Strip Resource Management Plan*, the Grand Canyon-Parashant National

Monument *Management Plan,* and the Vermilion Cliffs National Monument *Management Plan.* Grand Canyon staff members are participating in the planning process to address issues that involve both the park and subject lands. Until the revisions are complete, the 1992 *Resource Management Plan* remains in effect.

Of the BLM-administered lands adjacent to Grand Canyon National Park, the most affected by NPS management of the Colorado River is Grand Canyon-Parashant National Monument. Created in 2000, the 1,014,000-acre national monument lies north of western Grand Canyon and is managed jointly by the Bureau of Land Management and Lake Mead National Recreation Area. This remote area has no paved roads or facilities (other than Bar 10 Ranch; see below), and it receives relatively few visitors.

Grand Canyon-Parashant National Monument could potentially be affected by the updated *Colorado River Management Plan* primarily because of potential changes to helicopter passenger exchanges in the Whitmore area. The passengers are currently ferried between the Colorado River and Bar 10 Ranch (see description under "Socioeconomic Conditions"). The site is relatively isolated, accessible only by air and an 80-mile-long dirt road to St. George Utah. River trip passengers generally travel to and from the ranch by twin-engine, fixed-wing aircraft, which use a 4,200-foot airstrip on ranch property. All Bar 10 air traffic passes over Grand Canyon-Parashant National Monument, with most flights originating and ending in Las Vegas, Nevada.

The Colorado River is also accessible in the Whitmore area by an approximately 0.75-mile-long trail that ascends the north wall of the canyon in Grand Canyon National Park. The trailhead on the rim is on the boundary between Grand Canyon National Park and Grand Canyon-Parashant National Monument. Before 1985, when the helicopter ferry service was initiated, the owners of Bar 10 Ranch transported river trip passengers by mule on this trail, then bused them to the airstrip at the ranch. Some river trips still offer passengers the option of hiking out on the trail rather than using the helicopter. The Bar 10 Ranch is approximately 9 miles from the trailhead via a four-wheel-drive road across monument land. Beyond the ranch, the unpaved roads to St. George and communities along Arizona Highway 389 cross monument, BLM, state, and private lands.

Currently, Grand Canyon National Park personnel are working closely with BLM and Lake Mead personnel in preparing a management plan for Grand Canyon-Parashant National Monument. The purpose is to coordinate planning on issues surrounding use of the Whitmore area, passenger exchanges, overflights, and use of monument roads.

U.S. FOREST SERVICE — KAIBAB NATIONAL FOREST

Two units of the Kaibab National Forest border Grand Canyon National Park — the Tusayan ranger district on the South Rim (approximately 326,000 acres) and the North Kaibab ranger district on the North Rim (approximately 646,400 acres). A few rim-to-river trails occasionally used by river runners require crossing national forest land to reach the trailhead. One such trail, Nankoweap, crosses the Saddle Mountain Wilderness in the North Kaibab ranger district. No statistics are available on the number of river-related hikers using national forest trails, but it is

likely a very small proportion of total use. Compared to several other routes in and out of the canyon, these trails are long and difficult, and lengthy drives over primitive roads are required to reach the trailheads. Use is predominantly by backpackers. The principal management document is the 1987 *Kaibab National Forest Land and Resource Management Plan.*

NAVAJO INDIAN RESERVATION

The 12.5 million-acre Navajo Indian Reservation borders Grand Canyon National Park along the eastern bank of the Colorado River from RM 0 near Lees Ferry to RM 61.5 at the confluence of the Little Colorado River. The Department of the Interior has determined that the boundary between the Navajo Nation and Grand Canyon National Park generally lies 0.25 mile east of the historic high waterline on the Colorado River's eastern bank. Relatively few campsites and attraction sites are located on the Navajo Reservation within the canyon, but river runners do explore some side canyons, and some may venture more than 0.25 mile from the river. A limited number of noncommercial river runners also use river-to-rim trails that cross Navajo lands (e.g., Eminence Break, Salt Trail). Grand Canyon rangers at Lees Ferry inform boaters that if they travel 0.25 mile above the pre-dam high water line between Lees Ferry and the Little Colorado River they are on Navajo Nation lands, and hiking and camping on Navajo lands requires a permit from the Navajo Parks and Recreation Department. Given the remoteness of the area and the shortage of enforcement personnel, noncompliance appears to be common. Non-permitted use of tribal lands is considered trespassing by the Navajo Nation and is a concern to local residents. Where the Colorado River is accessible from the rim (e.g., Jackass Canyon), anglers and hikers are frequent visitors to the river, sometimes competing with river runners for campsites.

HAVASUPAI INDIAN RESERVATION

The 188,077-acre Havasupai Indian Reservation is located within and along the rim of Grand Canyon, south of the national park. The reservation is reached from the river by hiking up Havasu Canyon approximately 4 miles. Day hikers often venture onto tribal land to enjoy Havasu Creek's spectacular waterfalls, although the hike is a relatively long one: 8 miles round-trip to Beaver Falls, 12 miles round-trip to Mooney Falls, 14 miles round-trip to Havasu Falls, and 18 miles round-trip to Supai village. Some river runners are known to leave or join river trips by way of the reservation. A fee is required for entering Havasupai property, but people approaching from the river have often ignored this. As resources allow, the tribe stations personnel at the reservation boundary to ensure compliance, and NPS personnel inform commercial and noncommercial trips of this required fee. Camping within the Havasupai Indian Reservation is permitted only in designated campgrounds.

HUALAPAI INDIAN RESERVATION

The Hualapai Tribe occupies a 992,463-acre reservation south of the Colorado River. According to the "Memorandum of Understanding between the Hualapai Tribe, Grand Canyon National Park, and Lake Mead National Recreation Area," signed in September 2000:

> The Hualapai Tribe and the DOI [U.S. Department of the Interior] disagree on the location of the boundary between the Hualapai Indian Reservation and GRCA. . . . Accordingly, both the Hualapai Tribe and DOI claim jurisdictional authority from about River Mile 164.5 to about River Mile 273.5 from the center of the river to the highwater [sic] mark on river left. . . . To reduce further conflict on this issue, and to work towards a productive relationship, the parties have committed themselves to mutual management of an Area of Cooperation [AOC] to minimize the practical and operational impact of the boundary dispute. . . . The initial AOC as mutually agreed upon by the parties includes the area from the high water mark to high water mark from about River Mile 164.5 to River Mile 277 and that part of Lake Mead from River Mile 277 to Pearce Ferry. (Hualapai Tribe, Grand Canyon National Park, and Lake Mead National Recreation Area 2000, 2)

Management issues pertaining to the Area of Cooperation are addressed in meetings of a standing federal-tribal Core Team, which includes representatives of the Hualapai Tribe, Grand Canyon National Park, and Lake Mead National Recreation Area. The Core Team meets at least quarterly. Procedural steps for facilitating negotiation and consensus building among the parties are outlined in the "Memorandum of Understanding." It is agreed that the Hualapai Tribe must approve access to lands above the historic high-water line between RM 164.5 and RM 273.5 on south side of the river. River parties launching at Lees Ferry are informed of this restriction by the NPS rangers; however, enforcement is difficult because of the remoteness and size of the area. Infractions in side canyon locations except Diamond Creek are likely commonplace.

An 18-mile-long, unpaved road on tribal land from Peach Springs, Arizona, to the mouth Diamond Creek (RM 226) provides the first vehicle access to the river below Lees Ferry. Diamond Creek, therefore, is used as the primary takeout point by river trips, especially non-motorized parties. Trips bypassing Diamond Creek must travel an additional 54 miles to the next takeout opportunity at Pearce Ferry (now closed due to low water) or more than 70 miles to South Cove. Diamond Creek is also a launching point for trips running just the Lower Gorge. The permit system for noncommercial trips starting at Diamond Creek is handled cooperatively by the Hualapai Tribe and Grand Canyon National Park and is entirely separate from the permit system for launches at Lees Ferry. Hualapai River Runners, a Hualapai tribal enterprise, operates the only commercial trips launched at Diamond Creek.

Several problems are associated with the heavy dependence of river users on Diamond Creek. Occasional road washouts, particularly during the summer rainy season when use is heaviest, can make it unreliable for takeouts. Crowding is a growing problem. Space at Diamond Creek is extremely limited both for boats and vehicles, and the closure of Pearce Ferry and the expansion of Hualapai operations have increased demand for the use of this site. Non-tribal use can interfere with the launching of Hualapai river trips and may diminish opportunities for tribal members to use the beach. Other issues of concern to the Hualapai Tribe include road damage from heavy vehicles; costs associated with road repair, trash pick-up, and rescuing disabled vehicles; noise, pollution, and safety problems associated with traffic passing through Peach Springs; and potential harm to culturally sensitive sites. The Hualapai Tribe charges fees for all non-tribal use of Diamond Creek facilities.

Several commercial outfitters exchange passengers at the Whitmore helipad, south of the river on Hualapai tribal land. Since 1995, approximately 10,000 passengers have been exchanged annually at this location during the commercial primary season (May through mid-September).

Individuals leaving trips are flown to the airstrip at the Bar 10 Ranch as described above. Additional helipads are located on Hualapai land downstream of Diamond Creek in the Quartermaster area. It is estimated that 600–800 helicopter flights a week land and take off from 15 helipads at this mile-long site near the river. Tour flights to the Quartermaster area originate from Las Vegas, Nevada, and from Grand Canyon West, a Hualapai resort facility on tribal land on the South Rim of the canyon. The helicopters fly tourists into Grand Canyon for picnics and Hualapai-operated pontoon boat rides, and shuttle HRR passengers out of the canyon. The Hualapai Tribe maintains two floating docks (at RM 262 and RM 263) and several boats in the Quartermaster area. Neither the helicopter operations nor the boat operations are licensed or regulated by the National Park Service. (See the "Socioeconomic Conditions" and "Visitor Use and Experience" sections of this chapter for more information about river-related operations of the Hualapai Tribe.)